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PhD Thesis
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Supervisor Keith Goffin

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ABSTRACT

In order for firms to remain competitive CEOs acknowledge the importance of innovation. In life science R&D firms scientists are crucial for innovation because they hold knowledge to create competitive new products. They are also known to fall outside of full control of management. Therefore, understanding the role of the CEO in innovation in life science R&D is key to understanding innovation in these firms.

In order to gain insight into the role of the CEO a comprehensive review of the literature was conducted. It showed that the role of the CEO was mainly explored by means of survey-based investigations. The knowledge thus obtained has not offered insight into what CEOs actually do to lead innovation in life science R&D firms, nor does it take into account how it is perceived by R&D.

It was therefore decided to conduct structured interviews of 15 CEOs of life science R&D firms to obtain a better understanding of what they actually do to lead innovation. Their views were contrasted against the perceptions of 33 R&D managers who report to the CEOs. It was found that CEOs need to make considerable use of their absorptive capacity to lead innovation and that they use this capacity to focus R&D. The R&D function refers to the need for the CEO's absorptive capacity but emphasizes a relationship with the CEO based on trust.

The unique contribution of this research is that not only takes into account the view of the CEO but also of the R&D function. For academics, it opens new avenues for research in innovation using CEO absorptive capacity. For practitioners, it advises CEOs to make efforts to improve their absorptive capacity in order to be able to lead innovation in life science R&D firms.

Acknowledgments

My sincerest gratitude goes to Professor Keith Goffin. The times that we discussed the research were most enjoyable and intellectually rewarding. The support that I received from him was phenomenal and the continuous wish to make this research and this thesis better and better, again and again, resonated with me. Under his supervision and encouragements, I rewrote the text and rethought the research design over and over again until we both agreed that I was almost there... then to start all over again because it could still be improved. This was great. I enjoyed every single minute. Thanks so much Keith!

I am also very grateful to Professor Patrick Reinmoeller and Professor Andrew Kakabadse for their critical comments. It was a real joy listening to their arguments and I absorbed every single word. That is why – at the end of each panel review meeting – when they asked me whether I had any additional questions, I usually replied by arguing that 'I will think it over', so much was I impressed with their knowledge that I had to let it settle in for a while before I could eventually make sense of it.

A major 'thank you' goes to the Professors and lecturers of the Cranfield School of Management whom I enjoyed so much listening to and who were such excellent teachers: Professors Donna Ladkin, David Buchanan and Mark Jenkins and – of course – the late Professor Alan Harrison. And still others: Nardine Collier, Dr. Catarina Figueira, Dr. Jonathan Lupson, Dr. Carlos Mena, Dr. Colin Pilbeam, Dr. Emma Parry, Dr. Marek Szwejczewski, Dr. John Towriss and Dr. Chris van der Hoven and Professor Rick Mitchell (Cambridge University, UK). How could I forget those who made life easy while conducting the research: Barbara Birtles, Maggie Neale, Alison Wilkerson, Wendy Habgood, Heather Woodfield, Anita Beal, Sandra Bettison and many more. To Mike, Nneka, Pauline, Irineu, Patrick, Ruth, Munir, Ricardo, Edgar and Anton: thank you for the good times and your friendship!

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1 Introduction

1.1 The nature of the phenomenon and the reason for this research

1.1.1 The role of the CEO: supervising projects you don't understand

The problem of the role of the CEO in innovation in life science R&D firms can best be illustrated by the following case (Loch et al., 2011):

> 'At one point during the development of a new drug, both the vice president for drug discovery and the vice president for drug development of a life science R&D firm were confronted with new trial data that hinted toward heart-damaging effects of the drug candidate. Both went to the CEO who had the supervisory role of the project seen its importance for the firm's future. However, the complexity of the problem was such that the CEO asked his vice presidents to take the decision. Both decided to introduce the drug into the market but with damaging effects for the company. While the CEO decided to trust his scientific top management and hoped that they would be able to control the situation, he abdicated his responsibility'

As Loch et al. argue, what this CEO actually meant was not that he trusted his management but that he implied: 'I do not understand any of this, so you make a decision' (Loch et al., 2011)[1]. The question whether CEOs play a role in innovation in the research and development of drugs, vaccines or diagnostics therefore is a valid one. Although it is generally believed they play a role, it is not yet clear how this is achieved and – if such a role exists – how it is discharged.

It could be argued that CEOs do not have to play a role as long as the R&D function operates along its objectives. They do not even have to understand the science behind R&D as well as they do not have to understand the specialized knowledge of supply chain management, IP, manufacturing or finance. However, firms are under constant pressure to innovate products driven as they are by intensified competition (Goffin and Mitchell, 2005). CEOs are therefore under constant pressure to find new ways to remain competitive. Abdicating their responsibility to the R&D function because of a lack of understanding is particularly risky as illustrated by the case above. Especially in new product development requiring high-tech approaches, this pressure translates into considerable budgets and high risks making the strategic choices of CEOs pivotal for a company's long-term survival.

When asked about their role in innovation CEOs generally offer a 'recipe' for innovation: articulate a vision, attract and keep the innovators, make funding available, set the boundaries and reward successful innovators (Berger et al., 2009). Surveys have shown that CEOs consider innovation as key in their efforts to remain competitive and invest more in customer insights than in any other functional area thereby stressing the need to innovate to address customer needs (IBM, 2013). CEOs also recognize the increasing

[1] This is reported in an INSEAD Faculty & Research Working Paper in which Loch et al. use an interview based investigation to describe how senior management handles projects that are difficult to understand.

complexity of life science R&D and feel that they are 'ill-equipped' to face the upcoming challenges. For example, life sciences CEOs anticipate much more complexity than they feel confident about handling and recognize that they lag behind their peers when it comes to simplifying products and processes to manage the complexity of life science R&D more effectively (IBM, 2010).

These findings are corroborated by data reported in a survey conducted by McKinsey (Barsh et al., 2008). It shows that most senior executives do not actively foster innovative behavior and few of them explicitly lead and manage the innovation process in their companies. About one-third say they manage innovation on an ad-hoc basis while another third manage innovation as part of their leadership's team agenda. Most executives however are disappointed in their ability to stimulate innovation and to create a culture of innovation.

In other words, CEOs do not seem to be in a position to innovate, especially when they have difficulty in handling the complexities of life science R&D and understanding what their R&D function is reporting. If this is the case, how do the CEOs lead innovation in life science R&D?

1.1.2 The role of the CEO in innovation as discussed in the scholarly literature

There has been considerable debate in the scholarly management literature on the impact of CEOs on innovation. Some argue that the impact of CEOs on innovation is that they are simply not very relevant in driving innovation and that the locus of innovation lies in the middle of the firm, with middle—and senior R&D scientists and engineers (Burgelman et al., 2004; Christensen and Diehl, 1997). More importantly, this group of knowledge workers seems to be a particular difficult group to manage seen its autonomous character and particular social practice (Styhre, 2005; Gabriel, 1999). Today, the common view of the role of the CEO in innovation is that they have an effect on innovation at the project level through their support of individuals and team working (Yadav et al., 2007; Hegarty and Hoffman, 1990; Montoya-Weiss and Calantone, 1994).

From the different innovation activities that can take place in an organization, this thesis focuses on innovations that are based upon the research of scientists and engineers and the development that lead to new products, i.e. on science-based product innovation ('SBPI'[2]). We do not distinguish between breakthrough and incremental innovation or between developed science-based innovation and developing science-based innovation. We argue that in the context of science-based product innovations, incremental vs breakthrough or developed vs developing science-based innovations does not matter. An example from the drug industry make this clear: whether new drugs are developed with a new therapeutic focus in mind or established drugs are reformulated using high tech drug delivery systems may not make much difference from a complexity point of view. In both cases, the breakthrough of a new therapeutic area or the 'incremental' innovation introduced in an established drug may be equally complex and full of risk and require similar leadership skills from the CEO. We decided to explore the leadership role of the CEO in science-based product innovation as we

[2] The abbreviation is proposed by Styhre (2009)

argue with Styhre (2005) that science-based innovation is a 'particular social practice entangled with mutually dependent resources: for example, ideologies, machinery, conceptual schemes, laboratory practices, political skills, narrative capabilities integrated in a semi-unified process that enables knowledge to be continued' which makes science-based organizations struggle with the integration of this 'particular' nature of innovation into business objectives.

The role of CEOs in innovation in a science-based R&D environment may be fundamentally different from the role of CEOs in other functions in the firm. In contrast with, for example, a supply chain unit, the R&D function can take initiatives that affect the direction of the entire company (Grove, 1996), making the CEO's role in innovation doubtful. In addition, scientists, especially those working in life science R&D environments, are educated to the highest academic level to act creatively and innovatively. Valuable knowledge and creative ideas are owned by middle level R&D scientists who are known as a particular difficult group to manage seen its autonomous and individualistic character and particular linguistic and social practices (Burgelman et al., 2004; Styhre, 2009). R&D scientists are also seen as a self-monitoring and enterprising group of agents, who fall outside full management control (Florida, 2004) and who have fiercely criticized the use of management practices (Uitdehaag, 2008). In other words, while the objective of finance, supply chain management and other functions in the firm is to align them with the strategy of the firm, the R&D function is capable to redirect the strategy because of its knowledge and creative capabilities. If on the one hand the R&D function represents powerful knowledge and ideas and does not require top management leadership, while on the other hand a CEO represents power and strategy wishing to impact on firm performance, how then does the most influential leader in the organization play a role in innovation?

This thesis is an attempt to better understand the role of the CEO in innovation in the context of life science R&D firms.

1.2 Literature

The literature only offers scarce information about the role of the CEO in environments of intensive R&D and in life science R&D firms in particular. The majority of the research focuses on the role of the CEO in innovation from the viewpoint of either CEO characteristics or from his/her leadership behavior. In both cases, the role of the CEO in innovation is explored by trying to link either CEO age, tenure or leadership behavior to innovational output, in an attempt to establish a model that could predict the level of innovation. This research was useful as it offered some insight into the effect of these parameters when compared with roles discharged by CEOs and when weighed against environmental variables such as non-for-profit or commercial organizations. This research concluded that - for example - CEO attitude towards innovation is a factor that impacts innovation. Besides attitude, other role behaviors such as involvement and commitment were studied but they were used in different industrial settings ranging from governmental organizations to banking to IT and it proved to be difficult – if not impossible – to identify CEO roles that impact innovation. More specifically, there is no data available how CEOs actually discharge their role in innovation in life science R&D

firms. This is hardly surprising as the methodology used until now to understand the role of the CEO in innovation may miss the point: trying to understand this role by looking for relationships between CEO age or leadership styles and innovation, as will be reported in chapter 2, does not shed light on what CEOs actually do. So the question what CEOs do in innovation, when its complexity is such that they have difficulties understanding it, is a valid one. Answering this question will be difficult to do using the research approaches reported in the literature as will be discussed in chapter 2 and so an alternative more descriptive research – what is the CEO actually doing to solve this challenge? – is required. This thesis attempts to fill that gap in the literature.

1.3 Research

The research is divided in 4 phases: literature review, research design, research & findings and contribution to theory and practice.

1.3.1 Literature review

In order to obtain a good overview of and insight in the current knowledge on the role of the CEO in innovation, a literature review was initiated that consisted of a traditional review and a systematic review of the literature. During the traditional review of the literature, the leadership literature was explored to inquire what data is available on innovation while the innovation leadership literature was explored to inquire what data is available on leadership. This traditional 'bifocal' review of the literature was then supplemented with a systematic review of the literature. It was assumed that by combining a traditional review with a systematic review, a clear picture of the available knowledge on the role of the CEO in innovation would be obtained. Based on this review, gaps were identified in the literature that are addressed by new research that deepens our insight into the CEO's role.

1.3.2 Research design

A research design is developed and a decision is taken how the research gap can be addressed. The question is asked whether the research is of a quantitative or qualitative and of a confirmatory or an exploratory nature and which methods are most suitable to investigate the phenomenon. A conceptual framework is identified that allows the findings to be structured along existing theoretical insights into the role of the CEOs.

1.3.3 Research and findings

The third phase consists of two steps. During a first step, CEOs of life science R&D firms are approached to inquire about their role of innovation. Doing so, the objective is to obtain insight into the actual role that CEOs play in innovation. During the second step, the R&D executives who report to the CEOs are invited to join the research project in an attempt to understand how R&D executives perceive their CEOs as drivers of innovation. This is particularly important seen the rather autonomous character of the R&D function in highly intensive R&D environments. The findings are collected, analyzed and discussed.

1.3.4 Contribution to theory and practice

A conceptual framework is developed that links the findings together, allows a theory to be build and further research to be conducted. The findings are also viewed from the angle of the practitioner and a number of recommendations are proposed for CEOs of life science R&D firms.

1.4 Objective

The objective of the research is threefold. The first objective is to obtain a better insight in the *actual* roles discharged by CEOs in innovation in life science R&D firms by approaching CEOs directly and having them describe their roles. The second objective is to develop a conceptual framework that helps our thinking about the role of CEOs and opens new avenues for research. The third objective is to generate knowledge that can be used for management practice and to assist CEOs in their management of innovation.

1.5 Expected contribution

The expected contribution of this research is threefold. First and foremost, it is my objective to clearly describe what CEOs do to lead innovation in life science R&D firms. Second, an attempt will be made to develop a conceptual framework on the role of the CEO in life science R&D firms (contribution to theory). In addition, I will put forward recommendations that allow CEOs to improve their impact on innovation in life science R&D firms (contribution to practice).

1.6 Structure of the thesis

This thesis is structured along six major parts and Figure 1-1 presents a schematic overview. The research starts with a systematic and traditional review of the literature on the role of the CEO in innovation (Chapter 2).

The research design is presented in Chapter 3. The review of the literature leads to 2 research projects, the first one exploring the role in innovation of 15 CEOs of life science R&D firms (Chapter 4). It is followed by a research project in which 33 senior R&D executives, who report to the CEOs, are inquired about the role of their CEOs (Chapter 5). The findings of both research projects are compared in Chapter 6. The thesis ends with a discussion and conclusion and presents the contribution to both theory and practice and a proposal for continued research in Chapter 7.

1.7 Structure of the document

This document is divided in three major parts that are linked to each other as described in the diagram below (Figure 1-2): the main text, the literature references and an Appendix. The Appendix contains data that are excluded from the main text to increase its readability. It contains 16 separate appendices covering for example:

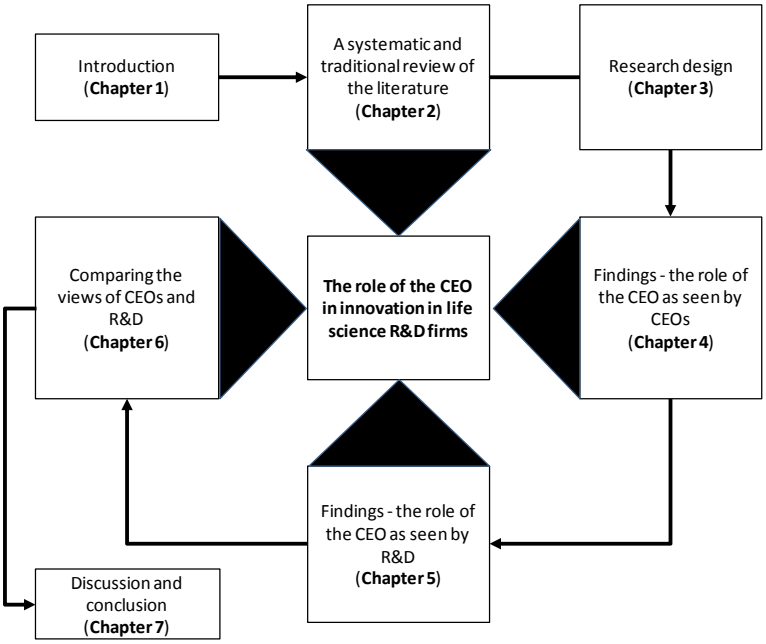

Figure 1-1 The structure of the thesis

i. a description of the procedures used for the literature review (A)
ii. a review of the outcome of the literature studies (B,C,D)
iii. a description of the research approach for the qualitative studies (E, F, J, L)
iv. interview observations of pilot CEO (n=2) and pilot R&D interviews (n=6) (E, L)
v. interview observations of the final CEO (n=15) and R&D interviews (n=33) (H, I, K, P)
vi. an overview of the interviewed CEOs and R&D executives (E, M)
vii. operational data of the interviews (interview time etc.) (G, N)
viii. the step-by-step categorization of R&D interview data (O)

The literature references refer to papers mentioned in the main text and to papers mentioned in the appendices.

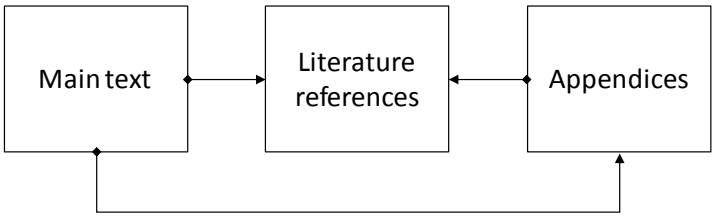

Figure 1-2 The structure of the document

1.8 Ontological and epistemological assumptions

This research starts from the ontological assumption that the external world consists of representations created by individual minds. According to Blakie (Blakie, 2007) 'whatever is regarded as being real is only because we think it is real; it is simply an idea

that has taken on the impression of being real'. As social actors 'socially construct their social reality', the epistemological grounding from which knowledge can be gathered is social constructivism or the inter-subjectively shared knowledge in that meaning giving is social rather than individual. For social constructionists, the source of knowledge of ideas is the product of the inter-subjective meaning giving activity of human beings in their everyday lives (Blakie, 2007).

1.9 Summary

The objective of the research is to deepen the insight of the actual role of the CEO in innovation in life science R&D firms, to contribute to the theory on the role of the CEO in innovation and to develop recommendations for CEOs to perform better in highly intensive R&D settings.

The core question that this research attempts to answer can therefore be summarized in the following general inquiry:

'How does a CEO discharge his/her role in innovation
in the context of a life science R&D firm?'

The nature of the question implies that the first and main objective of this research will be to obtain insight in what the actual role is of the CEO and how this role can best be described. The overall structure of the thesis that attempts to provide an answer to this inquiry is as follows. The thesis is divided in three main sections: the main text, the literature references and the appendices. The main text is divided in 7 chapters: an introduction in Chapter 1, the literature review in Chapter 2, the research design in Chapter 3, the findings in Chapter 4 and 5, a comparison of the findings in Chapter 6 and the discussion and conclusion in Chapter 7. The appendices contain data that presents supportive and detailed descriptions of the procedures, operational data, interview observations and other supplementary information.

2 Literature review

2.1 Introduction

In order to generate a comprehensive and accurate view of the role of the CEO in innovation[3], it was found necessary to combine a number of approaches in conducting what was termed a *bifocal* review of the literature. During a traditional review of the literature, the leadership literature was explored to inquire what data is available on innovation while the innovation leadership literature was explored to inquire what data is available on leadership. The traditional review was then supplemented with a systematic review of the literature. It was assumed that by combining a traditional review with a systematic review, a clear picture of the available knowledge on the role of the CEO in innovation would be obtained. This approach is presented in Figure 2-1 and the details of the procedure are explained in Appendix A. In addition to the traditional and systematic review of the literature, two additional literature reviews were conducted: one focusing on the context and leadership of R&D and another inquiring whether leadership theories, other than those currently used, can be of interest to explore the role of the CEO. The outcome of these reviews is structured as follows. First, the context of R&D is discussed in Section 2.2. and it is inquired whether research conducted in the context of R&D can help guide the research on the role of the CEO. Then, the results of the review of the literature on the role of the CEO are presented in Section 2.3. and it will be questioned whether there is an appropriate and promising theoretical perspective available to study the role of the CEO, a research gap worthwhile to explore and methodologies capable to do so. The conclusion and the research gap are presented in Section 2.4. The content of this chapter is summarized in Section 2.5.

2.2 The R&D function

Two scholarly works were helpful in laying the foundation of a better understanding of the context of R&D: Alvesson's work on knowledge intensive firms (Alvesson, 2004) and Styhre's on science-based innovation (Styhre, 2009). The discussion that follows borrows heavily from the ideas and concepts presented by these authors. In addition, it was felt that an understanding of leadership roles and styles used by middle and senior managers in R&D would be valuable for a better understanding of the role of the CEO because an understanding how leadership is effectuated at a lower level in R&D could enrich the understanding of the role of the CEO and eventually directs the research. Therefore the literature on leadership in R&D at the level of R&D teams and team leaders was also explored. In this case, the approach consisted of a search for recent review papers from which current research data can be retrieved. A review article by Elkins and Keller (2003) that addresses leadership in R&D was used.

[3] When reference is made to the 'role' of the CEO in innovation it should be recognized that the concept of role behaviour is used as a way to describe the influence that CEOs may have in the innovational process. According to Sheard and Kakabadse (2007), who studied the role based perspective of leadership in an industrial setting, top management members can be described by means of the 'roles' that they take on as part of the leadership that they discharge. This is further discussed in Chapter 3.

2.2.1 Science-based innovation

Whilst scientific research for the sake of intellectual curiosity was once predominantly an academic activity and Nobel Prize winners were selected among university scholars, an important and clear change took place during the last decades of the 20th century. Industry - and more specifically biotech firms - took part in the advancement of

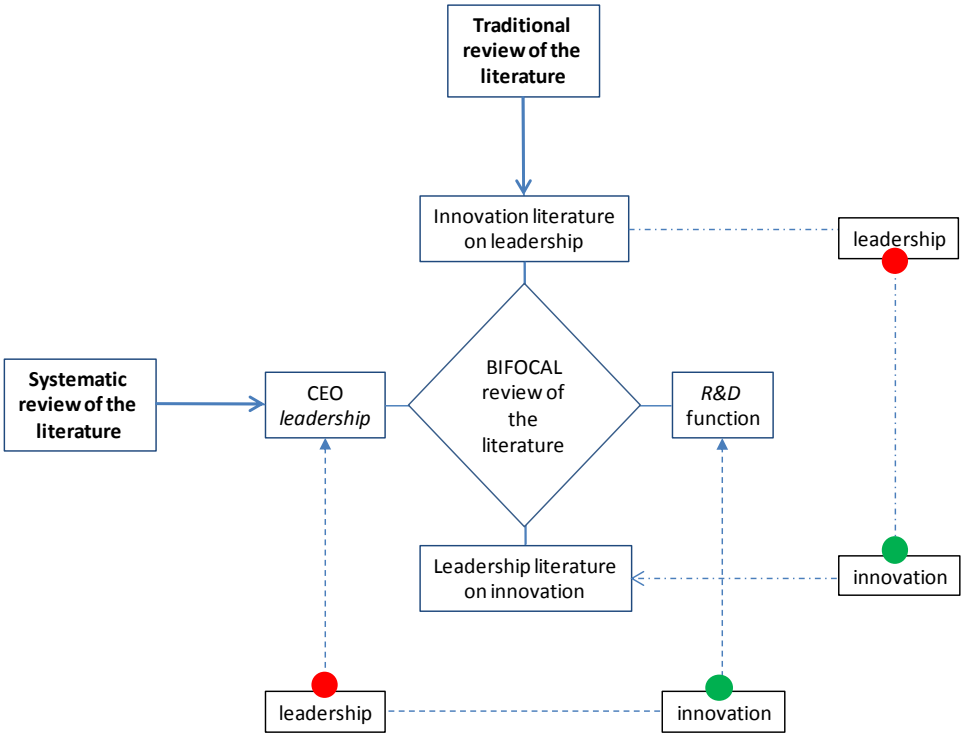

Figure 2-1 A bifocal review of the literature

science, an activity that was previously reserved for academic and not-for-profit institutions. This differs from the introduction of science into industry during the 19th century whereby scientific expertise and knowledge was used for the exploration of new commercial opportunities[4]. In contrast, during the 20th century, scientists at Chiron who invented the polymerase chain reaction[5] and Sir James Black[6] of Glaxo-Wellcome were awarded the Nobel Prize in medicine for extending our basic knowledge of biochemical phenomena (Pisano, 2006). These events were a sign of the time: science, as an activity that leads to knowledge ('truth') and to a better understanding of biological phenomena, was no longer the exclusive province of not-for-profit institutions; it was

[4] An example on how science led to commercial opportunities is presented in Jenny Uglow's book "The Lunar Men, The friends who made the future", Faber and Faber, 2003, London

[5] Polymerase Chain Reaction or PCR is one of the most important techniques used today in genetic research

[6] Sir James Black spent his career both as an industrial researcher and an academic. Black established the physiology department at the University of Glasgow and then went to work for ICI Pharmaceuticals in 1958 . He won the Nobel Prize for his scientific discoveries at ICI Pharmaceuticals in 1988.

now manifesting itself in the industry. Drug companies not only used new technologies to discover new drugs but also engaged in fundamental research to discover new targets and to develop techniques that broadened scientific knowledge. Whereas previously companies were recipients of new technologies, little by little they became developers of science and know-how. The sharp line that once differentiated academic and non-for-profit R&D institutions from commercial R&D corporations gradually disappeared (Pisano, 2006).

Firms that rely on their intellectual capital and capabilities as their central resource are known as knowledge intensive firms (or 'KIFs'). Alvesson defines KIFs as 'firms where work is said to be of an intellectual nature and where well-educated, qualified employees form the major part of the workforce' and 'typical examples of such companies are law and accounting firms, management, engineering and computer consultancy companies, advertising companies, R&D units and high tech companies' (Alvesson, 2004). Corporations who use a scientific-technological knowledge base are specific cases of KIFs and although some principles used to study KIFs may well apply to them, the nature of scientific practice precludes extending the statements made about KIFs into the world of science-based innovating firms (SBIF's). Oliver and Montgomery refer to these SBIF's as hybrid forms of corporations where 'advanced knowledge is generated by scientific professionals' and 'used in the creation of new products, such as in the biotechnology or computer industries' (Oliver and Montgomery, 2000). There is a difference between a set of specific skills and expertise on the one hand and a highly professional domain regulated and monitored by a series of institutions and stakeholders on the other hand (Styhre, 2009). An important characteristic of these firms is that 'they treat knowledge as a tool or instrumental resource aimed at providing some utility or serving some function' and that they are 'increasingly dependent upon their ability to develop, exploit and share particular knowledge bases'. However, there is a difference between knowledge as a general term and scientific competence since science operates along its own idiosyncratic and paradigmatic routes, guided by institutions and practices, so that one must not think that a KIF and a science-based corporation are synonyms (Styhre, 2009).

More specifically 'science-based product innovation is a social practice that is anchored in routines and institutions that are located outside of the particular firm while know-how in general may be local and situational, science-based innovation work is always already established qua legitimate social practice prior to its organizational inclusions' and 'science-based product innovation is a social practice with its own idiosyncratic and paradigmatic routines and operating within a field of expertise that is highly regulated, uses its own cultural and social interactions and procedures' (Styhre, 2009). In this regard, science-based innovation must be regarded as a field of scientific practice characterized 'by alliances, negotiations, political struggles, controversy, passions and desires, short-term gains and long-term strategies, quarrels over credibility and resources' and therefore, 'the influence of leadership in high performing scientific teams' should not be downgraded (Styhre, 2009). (In the present thesis, the term "R&D innovation" is considered synonymous with "science-based product innovation". The term "R&D function" is used to describe a group of scientists and engineers in middle-

and senior- R&D management engaged in and responsible for day-to-day scientific work in laboratories and workshops, as team members or as team leaders whose focus is to invent and develop products).

The sociology of science offers interesting insights into the professional conduct of scientists. Sociological studies of the activity of science are made by Merton (1973), Lenoir (1997) and Jasanoff (2005) (cited by Styhre, 2009). Latour and Woolgar (1979) posited that scientists work for peer recognition which eventually lead to career perspectives. This cycle of peer recognition that leads to increased research funding, which in turn translates into career perspectives, is called the credibility cycle of the scientific community. Some earlier sociologists of science, such as Bourdieu (1983) called this competition among scientists 'symbolic capital' or 'gift-exchanging'. Scientists make information available for free in return for 'gifts' such as recognition, prices or funding. Besides the symbolic capital built up by scientists as part of (peer) recognition and the potential for increased research funding associated with it, the extensive networking within the field of their expertise has been called social capital (Bourdieu, 1983)[7]. These scientific networks have been called 'invisible collages' (Crane, 1970) or 'communities of practice' (Wegner, 1998) and are used to exchange tacit knowledge, to nurture new knowledge, to further develop social capital and to stimulate innovation. There are different incentives for engaging in these networks: access to expertise, fertilisation across disciplines, better access to funds, obtaining prestige or visibility, acquisition of tacit knowledge about a technique, pooling knowledge for tackling large and complex problems, enhancement of productivity, student education, increased scientific specialisation and finally, fun and pleasure. May, Korzcynski and Frenkel (2002) observed that knowledge workers were committed to their corporations but even more so to their scientific communities beyond the boundaries of their firms; R&D scientists are therefore more likely to identify themselves with their peers in their respective scientific disciplines then with their own companies and their management.

2.2.2 Locus of innovation

Emphasizing the R&D function has been empirically linked with a competitive strategy of innovation (Martell et al., 1996). According to Styhre 'the crux with science-based innovation is that even though it may be organized and managed like any other organizational procedure or process, it still demands that some of the co-workers be willing to fully commit themselves to the project. Scientific breakthroughs are not a matter of administrative competence but of skilful scientific expertise, hard work, systematic routines and to some extent luck'. In addition, 'owing to the complexity of the work, senior managers frequently do not understand what actually goes on in the workplace and cannot rely on simple indirect, quantitative performance indicators to manage the process' (Styhre, 2009). 'Leadership in these firms differs from that in other organizations as the co-workers are professionals capable of executing their tasks on their own, making effective leadership potentially doubtful' (Alvesson, 2004). Especially for highly complex technologies encountered in drug research and development, R&D

[7] To the scientist, excellence is measured in terms of *primacy*. Researchers that are first to make a significant scientific discovery receive important rewards such as research grants, endowed chairs or fame (Mudambi and Swift, 2011)

personnel 'did not feel their managers were capable of seeing the full implications of the new tools and techniques' (Styhre, 2009). Often 'the majority of employees are capable of acting autonomously, and single individuals can sometimes take initiatives that affect the direction of the entire company' (Grove, 1996). A knowledge worker in science-based innovation therefore 'is a self-monitoring and enterprising agent, basically outside of the full control of management' (Florida, 2004). In line with this observation, Burgelman et al. observed that the locus of innovation lies in the middle of the firm, the levels that are comprised of middle- and senior-R&D scientists and engineers (Burgelman et al., 2004; Christensen and Diehl, 1997). In other words, if the locus of innovation is in middle-management, the question about the role of the CEO in innovation is a valid one, seen the hierarchical distance between the two actors[8].

One of the premises of this thesis is that the world of science – the micro-world of the science-based product innovators, scientists and engineers – is different from the world of business, the micro-world of the manager and the CEO and his/her top management team (TMT). This observation is addressed by Styhre (2009) in the context of high-tech spin-off companies as follows: 'The alliance of venture capitalists and researchers is a curious one in which venture capitalists initially did not really know how to evaluate scientific contributions such as journal publishing and conference presentations'. It illustrates a strange relationship between two actors who play in different theatres. Pisano comments on these very different worlds as follows: 'science-based businesses are challenged by rules, organizational technologies, and management practices' and 'science-based business entails unique challenges, that require different kinds of organizational and institutional arrangements and different approaches to management. Posed simply, what works well in other settings may not work as well in a science-based setting' (Pisano, 2006). In other words, if the world of science and technology is governed by its specific practice, conceptual frameworks, knowledge base, narratives, storytelling and writing (Alvesson, 2004), there is reason to believe that the top manager, as a generalist, has a limited role to play in the endeavors of this world. Consequently, the need of the R&D group for leadership by the CEO and its top management is posited to be minimal (Styhre, 2009).

2.2.3 Management and upward influence

The cultures of management and research do not mix very well and scientists have written vigorously against the use of management practices such as management control, implementation of control measures, rigorous execution and regular, consistent output (Uitdehaag, 2008, Bernal, 2007). R&D managers and CEOs belong to different 'professional guilds', subscribing to different belief systems and valuing different types of incentives (Mudambi and Swift, 2009). To management, excellence is measured in terms of market performance (Dasgupta and David, 1994; Gittelman and Kogut, 2003) while for the scientist, the knowledge creation process has intrinsic value (Duncan and James, 1974). Mudambi and Swift argue that the divergent interests of R&D scientists and firm management helps to understand why scientists can thwart management's

[8] In the life science industry, progress in R&D is difficult to observe, and managers are often unable to compel R&D project managers to truly disclose the prospects for long-run projects. Management rarely has currently available data that can be used to evaluate or refute project managers claims (Mudambi and Swift, 2011)

efforts to evaluate accurately R&D projects with scientific merit but little commercial value (Mudambi and Swift, 2011). In addition, seen the complexity of life science R&D, CEOs face an increasing difficulty to understand the science that governs the R&D in their firms and risk abdicating their responsibility (Loch et al., 2011). In contrast with accepted management practice, the R&D function consists of unforeseen outcome, luck, diverse ways of achieving targets and reward systems that do not fall into line with the reward systems of the rest of the firm's community. That does not mean that R&D scientists do not look for leadership in the classical sense but for a leadership that is capable of leading 'clever people'[9] by offering them the environment and resources necessary for experimentation without submitting them to rigorous procedural execution schemes and protocols and by allowing them to lead themselves (Uitdehaag, 2008; Goffee and Jones, 2007). Uitdehaag presents an analogy between 'warriors'[10] on the one hand, who, benefiting from sufficient training and using appropriate operational equipment, are capable of entering the battlefield where they make their own decisions and take up their own leadership, and scientists on the other hand, who consider that they lead themselves, encouraged by the fact that their knowledge cannot be grasped by top management, which is therefore unable to exercise control. The question however remains in how far R&D, seen the potential gap in knowledge between CEO and R&D, is capable to exercise upward influence because 'innovation is largely a process of influence' (Howell and Higgins, 1990) and to introduce the view of R&D into the strategy formulation of a firm. Lee and Bohlen (1997) define influence as 'the process by which people persuade others to follow their advice, accept their suggestions and comply with their orders'. Upward influence is defined as 'attempts to influence someone higher in the formal hierarchy of authority in the organization' (Porter et al, 1981). Championing is one form of upward influence that is intended to secure project support and project promotion (Floyd and Wooldridge, 1997) and successful project championing can lead to input into corporate strategy. Shim and Lee observed that R&D project leaders use different upward influence tactics but no data is available on the process and impact of upward influence from R&D to the CEO (Shim and Lee, 2001).

2.2.4 Roles and leadership

It is not desired to confine this study of the role of the CEO to 'the CEO's office' but rather to put him/her into the broader context of the firm and its R&D. It is argued that an understanding of leadership behavior and roles played by middle and senior R&D leaders is helpful in reaching an understanding of the role of the CEO because this role may be subject to an upward influence by R&D personnel (Shim and Lee, 2001). Also, an understanding of how leadership is discharged at a lower level in R&D, and how it is researched could enrich our understanding of the leadership of the CEO.

The management of scientists and engineers has long been a topic of interest in the management literature, Drucker having introduced the subject in 1985 (Drucker, 1985 cited by Styhre, 2009). There is also considerable literature on how to manage experts (Reed, 2007; Blackler, 1995; Mueller and Dyerson, 1999) but it offers little information

[9] The term "clever people" to denote R&D scientists is used by Uitdehaag, 2008

[10] The term "warrior" to denote R&D scientists is used by Uitdehaag, 2008

on what these experts do and how managers can gain insights into their activities (Styhre, 2009). The latter problem was addressed by the innovation literature in which management researchers specifically investigated leadership in the context of R&D in an effort to identify components of leadership that impact positively upon innovation. West et al. (2003) observed that leadership, i.e. the presence of an identifiable leader, is necessary for innovation to proceed. In the following sections, the roles played and leadership styles used by R&D team leaders are discussed.

2.2.4.1 Roles played by R&D team leaders

The innovation literature has approached the problem of leadership in a R&D context by addressing the roles that R&D team leaders discharge. The results can be summarized as follows:

i. When team leaders act as (product) champions and deliberately cross the boundaries of their teams, thereby interacting with the larger community in which their teams operate, they are more successful in keeping their projects on top management's list of priorities (Markham et al., 1991).

ii. When team leaders adopt a transformational leadership style and combine this with a championing activity, their projects are more successful, especially if they were able to obtain support from top management (Waldman and Atwater, 1992).

iii. When project leaders are technically less skilled, higher performance was associated with granting team members the freedom to explore new avenues for research in innovation (Andrews and Farris, 1967). When team leaders are technically highly skilled individuals, high innovation performance was associated with critical assessment of the work of subordinates. In highly innovative teams, supervisors were not regarded as the source of new innovative ideas during the stage of exploration and idea generation. However, during the later phases, when projects reached a more advanced stage of development, supervisors were considered important because of their critical evaluation and technical/administrative support (Farris, 1972).

iv. When a team leader creates a climate for innovation, a number of antecedents favoring innovation can be identified: vision, participative safety, a climate promoting excellence, operational autonomy/freedom, good project management, encouragement, organizational resources, recognition time, challenge and pressure (Elkins and Keller, 2003). The managerial practices considered necessary for an organizational culture to drive innovation include the creation of a sense of community by giving subordinates operational autonomy, personalized recognition, a continuity of slack resources and by ensuring group cohesiveness.

v. In a study in the pharmaceutical industry, Cardinal found a close relationship between the diversity of specialists in the R&D programs, contacts with outside

experts on the one hand, and both radical and incremental drug development innovations on the other (Cardinal, 2001).

In summary, the roles played by R&D team leaders refer to technical skills and product championing behavior as well as the capability to efficiently manage projects and set a climate for innovation such as participative safety, operational freedom and organizational resources.

2.2.4.2 Leadership styles used by R&D team leaders

Leadership researchers have explored transformational, path-goal and leader-member exchange (LMX) theory in a R&D context.

Transformational theory

Transformational theory was first articulated by Burns (1978) and later developed by Bass and Avolio (1994) into a leadership theory for organizations. Transformational leadership theory states that transformational leaders create personal and professional commitment from subordinates and increase their self-esteem and self-actualization (Bass and Avolio, 1994). It is now part of what Avolio et al. have defined as 'new genre leadership theory' (Avolio et al., 2009). This leadership style can be seen as an expansion or extension of transactional behavior which is characterised by the 'skill and ability required to handle the more mundane, operational, day-to-day transactions of daily life' (Kakabadse and Kakabadse, 1999). A transformational leader is capable of influencing followers by creating a connection between their self-concept and the mission of the organization or group and by modifying their values and self-esteem in such a way that these are aligned with the mission of the organization (Kark et al., 2003; Felfe and Goihl, 2002). Bass (Bass et al., 2003; Bass and Avolio, 1997) developed a model that allows conceptualization of the transformational leadership style by means of four dimensions: idealized influence, intellectual stimulation, individualised consideration, and inspirational motivation.

i. Idealised influence is based on the ability of a leader to evoke admiration, respect and trust in the followers,
ii. Intellectual stimulation refers to the ability of a leader to arouse within followers an awareness of problems and a recognition of their own beliefs and values (Bass and Avolio, 1994),
iii. Individualised consideration means that a leader gives personal attention to individuals, taking into account their differences (Felfe and Goihl, 2002; Bass, 1990; Felfe et al., 2004),
iv. Finally, inspirational motivation refer to the ability of a leader to create an inspiring vision of the future (Bass and Avolio, 1994).

Although transformational theory offers an interesting theoretical perspective for the study of leadership in innovation, and research has shown that transformational behavior improves leadership effectiveness (Bass and Avolio, 1997), not many studies have shown a consistent effect of this leadership style on innovation (Reuvers et al., 2008) although some showed an impact on employee creativity and innovation (Oldham and Cummings, 1996; Amabile et al., 1996; Zhou, 1998). The effectiveness of

transformational leadership in innovation was moderated by the level in the organization at which leadership was deployed and on the type of project (Keller, 1992). For example, transformational leadership style was positively related to project quality and budget/schedule performance. This relation seemed to be stronger for research projects than for development projects. Transactional leadership style on the other hand, was more important for development projects than for research projects. Intellectual stimulation, individualised consideration and charisma of senior R&D managers (but not team leaders) also play an important role in project success (Waldman and Atwater, 1992). According to Waldman and Bass (Waldman and Bass, 1991), transformational leadership is important in the early research stages when team leaders play a major role. During later phases of innovation, project success is supported by a charismatic leadership style displayed by higher-level members in the R&D organization. Project effectiveness therefore is linked to transformational leadership on the part of project leaders in the research phase and higher-level leaders in the development phase. However, only two studies have evidenced a link between transformational leadership and innovation (Janssen, 2002; Wilson-Evered et al., 2001) whilst other studies failed to support that hypothesis (Kahai et al., 2003; Jaskyte, 2004). Moreover, some findings point in the direction of a link between innovativeness and systematic management control, a behavior that is associated with transactional leadership behavior (Turner and Makhija, 2006; Gilson et al., 2005). In other words, empirical support for a strong, overall and general relationship between transformational leadership style and innovation is not available.

Path-goal theory

A second theoretical framework used to understand leadership in R&D context is path-goal theory. According to path-goal theory, an effective leader uses behaviors that facilitate goal attainment and maximise the value of this achievement, 'thereby affecting subordinates' expectancies, performance and satisfaction' (House, 1971; House, 1996). The theory suggests that leaders engage in different leadership styles warranted by the nature and demands of a given situation. These leadership styles may shift from directive to achievement-oriented to participative to supportive. Path-goal theory posits that a leader may use different styles according to the situation. The leadership styles have the following characteristics:

i. A directive path-goal leader is a leader who clarifies the goal that needs to be attained and the path that is best suited to achieve the goal.
ii. The achievement-orientation style refers to behaviors through which leaders set challenging goals, expect their subordinates to perform at the limit of their potential and show confidence in their capabilities.
iii. A participative leader involves his/her subordinates in the decision-making process and consults with them for suggestions in making these decisions.
iv. A supportive leader assures satisfaction of subordinates' needs and preferences and is concerned with their psychological well-being.

The leader-behavior relationship is moderated by environmental (task structure, authority system, work group) and follower characteristics (experience, locus of control,

ability). Effective leaders clarify the path to assist subordinates to achieve their goals, remove obstacles that hinder the achievement of goals and adapt their leadership style to environmental and subordinates' characteristics. However, path-goal theory has not enabled the study of the relationship between leadership and innovation to take a step forward. Path-goal theory assumes a close relationship between leader and follower and therefore its usefulness in exploring the role of the CEO who is separated several hierarchical levels from R&D middle-management is dubious. The theory therefore is posited to offer a poor starting point to study the role of the CEO in innovation.

LMX theory

A third approach is Leader-Member Exchange theory or 'LMX' and was introduced by Graen and Ulh-Bien (1991). It focuses on the social exchange in the relationship between supervisor and subordinate. The theory divides the social exchange process into three stages:

i. initial testing and evaluations of motives, attitudes and role expectations,
ii. development of trust, loyalty and respect, and
iii. development of mutual commitment to organizational units/goals (Graen and Uhl-Bien, 1991; House and Aditya, 1997).

According to LMX, it is the quality of the social exchange process between leader and follower that influences organizational outcomes (Graen and Uhl-Bien, 1995). The impact of the social exchange process on innovative behaviors and on subordinates' motivation and commitment was investigated by Yukl (2002). Several studies have made an attempt to elucidate the impact of factors in the social exchange processes on creativity and innovation (Amabile and Conti, 1999; Mumford and Gustafson, 1988), such as providing subordinates with challenging tasks (Liden and Graen, 1980), leader support in high-risk undertakings (Graen and Uhl-Bien, 1995), leaders who secure task-related resources (Graen and Scandura, 1987), recognition (Graen and Cashman, 1975) and supervisory advocacy (Duchon et al., 1986). Consistent with the above-noted prediction, it was found that a high-quality social exchange impacts positively on innovation and creativity. Scott and Bruce for example, observed that in a large R&D facility, a high quality exchange was related to innovative behavior and the perception of an organizational climate that supports innovation (Scott and Bruce, 1994). LMX theory offers a poor departure to study the role of the CEO because it assumes a close relationship between leader and follower which is assumed to be minimal between CEO and R&D seen the distant hierarchical levels.

2.2.5 Summary and conclusion

An overview of the theoretical perspectives used in the research of leadership R&D and their usefulness for CEO research in innovation is presented in Table 2-1. The main objection to using these leadership theories to study the role of the CEO in innovation is that they do not take into account the autonomous character of the R&D function, the individualistic character of scientists and its resistance to management leadership practices such as control and oversight. On the contrary, they are based upon a relationship between the leader and the follower in which the follower is willing to

accept – or undergo - managerial leadership behavior. In other words, the role of the CEO should be viewed against the perspective of the R&D function about that role.

2.3 The CEO

This section presents the results of both the traditional and systematic review of the literature and discusses the role of the CEO through the lens of upper echelon and leadership theory in Section 2.3.1. and 2.3.2. respectively. Section 2.3.3. compares the impact of CEO leadership with the impact of context on innovation. Section 2.3.4. explores CEO role behaviors and Section 2.3.5. concludes the findings.

2.3.1 Upper echelon theory

Some argue that organizational performance is not driven by leadership effects (Hall, 1977) and posit that organizational and environmental factors have more impact on firm outcomes (Kimberley, 1986): CEOs are subject to environmental constraints (Aldrich, 1979) and corporate performance owes little to CEO contributions (Galbraith, 1984). Studies that examine the impact of CEOs on innovation tend to focus on small-sized firms (Julian, 2005; Lefebvre and Lefebvre, 1992) as in small firms the influence of CEOs on the strategy and performance is higher and potentially more observable (Miller and Toulouse, 1986b). Recent research suggests that the impact of CEOs on innovation adoption and innovation may be significant in large organizations also (Damanpour and Schneider, 2006; Jung et al., 2008). Top managers are largely responsible for the cultural values that support innovation in their firms (Elenkov et al., 2005; Bantel and Jackson, 1989) and their personal characteristics, functional expertise, general management experience, and attitude towards change may influence the innovational climate (Ekvall and Ryhammar, 1999; Hoffman and Hegarty, 1993; West and Anderson, 1996). Hambrick and Mason (Hambrick and Mason, 1984) in response to the arguments that CEOs 'do not matter' and in an attempt to explore their role, put forward the upper-echelons perspective in which personal experiences, values and beliefs of managers influence their interpretations of situations and affect their decisions and choices.

Research conducted under the upper-echelons perspective uses demographic variables (e.g. age) and CEO characteristics (e.g. experience) instead of actual leadership behaviors (Cannella and Monroe, 1997) to assess the impact of CEO characteristics (demographic or personality) on strategy (Miller and Toulouse, 1986b), organizational culture (Deal & Kennedy, 1982), corporate norms (Tichy and Ulrich, 1975) and more generally providing effective leadership (Schein, 1985). It disclosed the effect of demographics on the adoption of innovation in firms (West et al., 2003; Scott and Bruce, 1994; Howell and Higgins, 1990; Bantel and Jackson, 1989) and led to a wide variety of studies linking CEO demographics and characteristics with measures of innovation. Appendix B offers a detailed - granular - overview of upper echelon research and innovation.

Author	Sample	Dependent variables	Findings & comments	Usefulness for CEO research
Transformational theory				
Keller (1992)	Sample 1: 462 professional employees from 66 project groups from 3 industrial R&D organizations; Sample 2: 440 professional employees from 61 project groups from three industrial R&D organizations	Project group performance (ratings of project quality and budget/schedule performance by project members and managers)	Transformational leadership of project leader is positively related to project quality and budget/schedule performance. The relationship between transformational leadership and project quality is stronger for research projects than for development projects.	Yes
Waldman and Atwater (1992)	Interviews: 40 project members, leaders and higher-level managers in R&D units of two organizations; Surveys: 147 project members, leaders and higher-level managers in R&D units	R&D project effectiveness (ratings by higher-level managers)	Transformational leadership an championing behavior is positively related to project effectiveness	
Path-goal theory				
Keller (1989)	477 professional employees from four R&D organizations	Job satisfaction and employee performance	Need for clarity moderated the relationship between initiating structure and job satisfaction and between initiating structure and performance	No
LMX theory				
Scott and Bruce (1994)	172 engineers, scientists, and technicians and 26 managers at an R&D facility of a US industrial corporation	Innovative behavior (ratings by managers) and climate for innovation (ratings of subordinates)	Positive relationship between high quality LMX and innovative behavior and also climate for innovation. Positive relationship between supervisor's expectations and innovative behavior of technicians	No
Scott and Bruce (1998)	Sample 1: 110 R&D engineers and R&D scientists and 22 managers of a US industrial corporation; Sample 2: 149 R&D engineers and 26 managers at an electronic equipment manufacturing company	Innovative behavior (ratings by managers)	Positive relationship between high-quality LMX and innovative behavior	
Tierney et al. (1999)	191 research managers, research scientists, section leaders, project leaders, work group professionals, and work group technicians in the R&D sector of a chemical corporation	Creativity as measured by ratings by managers, invention disclosure forms and number of research reports	Positive relationship between high-quality LMX and creativity for adaptors	

Table 2-1 Empirical investigations of leadership in R&D

2.3.2 Leadership theories

2.3.2.1 Transformational leadership theory

In the previous section, the impact on innovation of CEO characteristics (demographics, tenure etc.) was discussed as part of the upper echelon perspective. These individual characteristics may impact the relationship between a CEO and his/her subordinates, but CEOs with similar demographics can manifest their leadership styles and behaviors in different ways. This section addresses the impact of CEO leadership styles on

innovation. In the section on R&D (2.2) it was shown that R&D team leaders who exhibit transformational behavior may impact innovation. Until now transformational leadership styles have been studied mostly at the level of employees or organizational subunits. However, Jung et al. (2008) showed that there is a positive relationship between the transformational leadership style of the CEO and organizational innovation. However, the existence of such a relationship does not necessarily imply causality. The empirical data that show or point to an impact of a given leadership style of the CEO on firm innovation are limited. Although data suggest an impact of a transformational CEO on innovation, there is no understanding how this impacts innovation in middle management R&D, considered the locus of innovation (Burgelman et al, 2004). This assumes the CEO's impact on the top management team and from there to percolate through the organization, making the transformational leadership style by the CEO 'felt' in the more distant (lower) layers of the organization. However, no research data support this proposition. There is also no research data that show impact of the R&D function on the leadership style of a CEO.

The step from project level - where the transformational leadership style was found to have potential impact impact on innovation - to firm level is substantial and it is questionable whether the tentative conclusions reached at the team level apply at firm level. Ling et al. (Ling et al. 2008) argue that the mechanisms underlying the transformational impact of the CEO on innovational output remain largely unexplored, and given that the individuals most closely influenced by a firm's CEO are its top management team (TMT) members, they focused on the CEO-TMT interface. Although Jung et al. (2008) alluded to the possible impact of transformational leadership of the CEO on innovation, the mechanism of this impact is still not understood and it is needed to delve more deeply into the organization. In line with this reasoning, Ling et al. posited that transformational CEOs influence TMTs' behavioral integration, risk propensity and decentralization of responsibilities. In addition, a TMT's shared preference for risky growth opportunities is likely to be encouraged by transformational CEOs and such leaders possess both a vision and a measured degree of optimism about change, and they tend to communicate inspirational messages that both challenge TMT members to think 'outside of the box' and instill in them the confidence that obstacles can be overcome (Bass, 1985). Ling et al. argue that when a transformational CEO stimulates TMT members' efforts to be innovative and creative by questioning the team's assumptions, reframing problems and facilitating consideration of new ways to approach existing situations, the leader helps to alleviate some of the concerns they have about such undertakings (Amabile, 1998), thereby increasing the TMT's propensity to take risks. In their analysis of 152 firms in which CEOs had held their positions for 14 years on average, CEO transformational leadership was positively associated with risk propensity.

2.3.2.2 Alternative leadership theories

Besides transformational theory, other theoretical approaches may be useful to study the CEO in innovation. It was already argued in Section 2.2. that path-goal and LMX theory would not be ideal candidates as theoretical frameworks, but other theories may be. An analysis of alternative leadership theories is included in Appendix C. The

conclusion drawn from this analysis is that the majority of the leadership theories were not developed to study a key individual such as the CEO in the context of innovation and it would be difficult if not impossible to use these frameworks to explore his/her role. However, some theories do offer interesting avenues to explore the role of the CEO because they study leadership from a viewpoint of roles such as Sheard and Kakabadse's role-based leadership theory or because they put the CEO in the middle of their focus such as Arendt et al.'s CEO-adviser model (Sheard and Kakabadse, 2007; Arendt et al., 2005). The latter model states that the CEO is not the ultimate and isolated strategy formulator nor an 'over-socialized' decision maker but rather a strategy formulator who acts in the center of a network of advisers at different levels in- and outside of the firm. Because of this interesting perspective for our research, Arendt et al.'s model will be described in more detail in Chapter 3.

2.3.3 The impact of context

In the exploration of the impact of demographics on innovation, it was observed that context plays an important role. For example, it was only when firm context was taken into account, that CEO age and tenure became factors of influence and potential predictors of innovation (DeTienne and Koberg, 2002). For scholars of the environmental determinism school, the role of top managers is limited to 'an effort to combine techno-economic factors which, if it is successful, enables the organization, considered as an open system, to equilibrate or match its internal resources with the requirements of the external environment, thereby assuring the survival of the organization' (Papadakis and Bourantas, 1998). On the other hand, strategic-choice theorists emphasize the role of the strategic-decision makers and argue that the decision-making process is influenced by demography and personality traits. The strategic-choice perspective however does not make the impact of organizational and/or environmental characteristics obsolete. The question, therefore, is not necessarily whether top managers matter, but 'how much they matter in a specific context' (Gupta and Govindarajan, 1984). In other words, there is reason to believe that both CEO characteristics (personality and demographics) and contextual variables (organizational and environmental) play a role in innovation. Consequently, the main issue, as far as the impact of CEO characteristics on innovation is concerned, is how this impact compares with the impact of organizational and environmental factors. Hage and Dewar (1973) suggest that among organizational, environmental and leader factors, the leadership factor was an important predictor of innovation in an organization. Lefebvre and Lefebvre (1992) observed that the entrepreneurial mindset of CEOs, their attitude towards risk, their locus of control and their engineering/production experience and the nature of their decision-making process explain the largest component of the variance in firm innovativeness, whilst firm characteristics only marginally impact the firm's innovation level. Lefebvre and Lefebvre built further on a number of studies investigating the role of the CEO and their positive influence on firms (Maidique and Hayes, 1984) and negative influence on technological developments (Meyer and Goes, 1988; Bakos and Treacy, 1986). Top management characteristics proved to impact strategic influence on innovation more than corporate practices do. No data could be retrieved from the literature that showed the impact of the specific context of life

science R&D on the emergence of specific leadership styles discharged by CEOs. This is not surprising as studies that attempt to explore leadership in these settings start from the premise of a leadership theory which is then tested in a specific context. In order to assess whether a specific context leads to specific role behaviors, another approach is required as was shown by Sheard and Kakabadse (2007) who described different types of roles taken up by senior managers in a specific context. Sheard and Kakabadse were able to observe and identify these roles using qualitative based research (interviews) which then led to the description of very specific roles (identified as 'macro, legitimate, social, task'). Their research was entirely descriptive in nature and showed how senior managers behave in the context of intensive managerial networks.

The following sections address the organizational and environmental context in which the CEO plays his/her role. First, the macro- context of the firm and environment is discussed followed by the micro-context of the top management team and the board.

2.3.3.1 Macro-context

Two studies are presented that address the comparative impact of leadership and context on innovation.

Comparison of the impact of the CEO attitude and of context on innovation

Damanpour and Schneider (2006) compared the influence of environmental and organizational characteristics with top managers' characteristics on the initiation, adoption decision and implementation of innovation. They observed that the external environment, organizational characteristics and top manager demographics contribute to the initiation, adoption, decision and implementation of innovation. However, CEO personality data, such as attitude towards innovation, contribute substantially to innovation and it became clear that CEO attitude towards innovation is a predictor of innovation, more than environmental and organizational factors or CEO demographics. This shows that CEO demographics have only a limited effect on innovation as compared with CEO personality characteristics and environmental/firm characteristics. The data also show that CEO's age does not impact negatively on innovation, i.e. older CEOs do not necessarily reduce innovational output. In addition, there was no gender impact innovation and the level of CEO education did not influence innovation positively, whilst CEO tenure did not impact negatively on innovation.

Whereas Damanpour and Schneider compared the impact of environmental and firm characteristics with CEO characteristics (demographics or personality), another study conducted by Papadakis and Bourantas (1998) attempted to weigh the relative impact of CEO characteristics and of organizational and environmental variables on new product innovation (NPI), significant product innovation (SPI), incremental product innovation (IPI) and on innovations in production processes (IPP). It was found that CEO characteristics significantly influenced NPI, but that the organizational and environmental context was more influential. However, none of the CEO demographics such as tenure and the level of education, had a significant effect on innovative behavior (NPI, SPI, IPI, IPP), whereas CEO personality characteristics such as need for achievement, goal of reputation and goal of power appeared to be strongly linked with

innovative behavior. Papadakis and Bourantas also introduced the principle of CEO discretion into the study of the role of the CEO in innovation. The authors linked the principle of discretion to firm size, realising that in smaller firms, the power of the CEO and his/her latitude in making decisions that impact the strategic direction, are greater. CEO personality characteristics are more important than CEO demographics in fostering new product innovation, and are found to be more important than contextual factors.

The observations made by Damanpour and Schneider and by Papadakis and Bourantas are schematically presented in Figure 2-2 (the width of the arrows indicate the impact of the parameter on the innovation in general or on new product innovation). In summary, CEO demographics seem to be a poor predictor of innovation, whilst CEO attitude towards innovation and the appropriate organizational environment are important drivers of innovation. New product introduction is driven to a greater extent by CEO personality than by organizational and environmental characteristics. A detailed comparative study of the data obtained by the Damanpour and Schneider and by Papadakis and Bourantas is presented in Appendix B.

The combined effect of CEO and context

The question can be asked whether CEO characteristics and context, when taken together, play a role in innovation. For example, is the impact on innovation of a younger CEO in a young company higher than the impact of an older CEO in a mature firm? Detienne and Koberg (2002) conducted a study in three industries (aerospace, telecommunications and electronics) to assess the impact of environmental and organizational variables and managerial characteristics, such as age and tenure, on discontinuous innovation. Detienne and Koberg inquired whether CEO demographics, such as the age of the CEO, impact upon the level of discontinuous innovation because, they argued, following Bantel and Jackson, that younger managers 'typically have less commitment to the status quo and adopt favourable attitudes toward a greater risk orientation that favours innovation' (Bantel and Jackson, 1989). In addition, it was argued that tenure of the CEO impacts on innovation because 'by virtue of their personal characteristics, managers will vary in the degree to which they develop and promote different types of innovation' (DeTienne and Koberg, 2002). Long CEO tenure seems to be associated with conformance to maintaining current performance (Finkelstein and Hambrick, 1990), whereas short CEO tenure overcomes inertia and allows strategic change to take place (Wiersema and Bird, 1996). Detienne and Koberg observed that organizational characteristics such as firm age and size and intrafirm structural linkages explain the variance in discontinuous innovation to a greater extent than environmental dynamism. Firm process capabilities such as improvisation, experimentation and transitioning between development phases can explain variances in discontinuous innovations among firms but to a degree comparable to firm size and age and intrastructural linkages. Managerial demographics, however, such as CEO age and tenure, were not a significant factor in explaining discontinuous innovation variance.

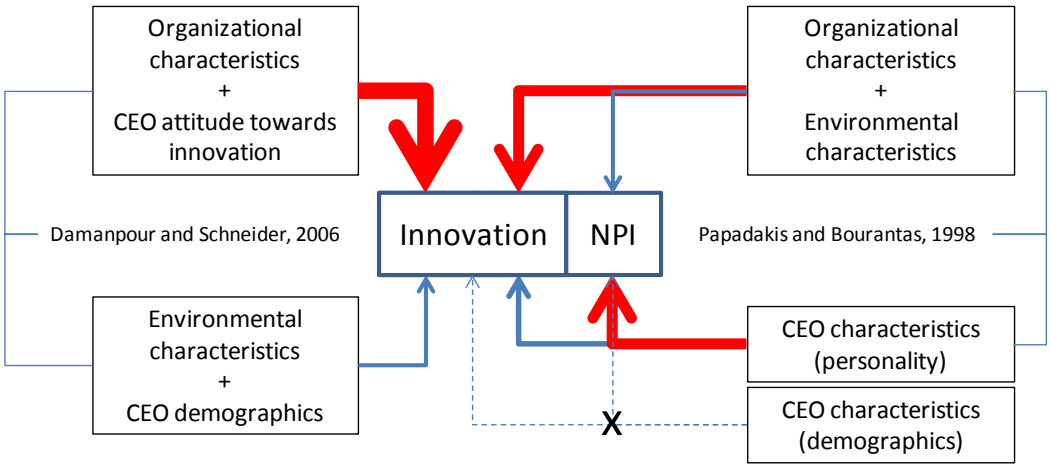

Figure 2-2 The impact of CEO variables and organization/environment on innovation

After further analysis, Detienne and Koberg showed that discontinuous innovation:

i. decreases with the age of the firm but more rapidly with older CEOs,
ii. decreases with the size of the firm and more rapidly with long-tenured CEOs,
iii. increases with the number of intra-firm linkages and more rapidly with younger CEOs.

The effect of CEO tenure was explored in more detail by Wu et al. (2005) who hypothesised an inverted U-shaped relationship between CEO tenure and innovative output as predicted by Hambrick and Fukutomi (1991). It was found that the inverted U-shape relationship is moderated by the dynamics of the environment. For example, in a technologically dynamic environment short-tenured CEOs fostered innovation more than long-tenured CEOs, while in technologically stable environments, long-tenured CEOs generated more innovative output than short-tenured CEOs. With increasing CEO tenure, the firm's innovativeness increases during a first phase but starts to decrease with prolonged CEO tenure. In high-dynamic environments, the longer the CEO tenure, the more dramatic the decrease in the firm's inventiveness, whereas in low-dynamic environments, the increase in CEO tenure increases the firm's inventiveness but levels off with long CEO tenure.

Not only upper-echelon based research showed that context plays a role in the impact of CEO demographics on innovation, studies using transformational theory also point into the direction of an effect of context upon the impact of transformational leadership of the CEO on innovation. Jung et al. (2008) showed that the environment (uncertainty and competition) and firm characteristics (such as innovational climate, formalisation, centralisation and empowerment) have moderating effects on the relationship.

During a longitudinal research of companies exposed to the new and emerging technology of fibre optics, Eggers and Kaplan (Eggers and Kaplan, 2009) observed that both the CEO's attention to new emerging technologies and organizational orientation are important factors in understanding a firm's response to new technical opportunities,

and that considering them simultaneously provides a more nuanced understanding of their relative and interrelated effects.

2.3.3.2 Micro-context

As the CEO is a member of a top management team (TMT), the impact of other high-level leaders in his/her team and their interactions with him/her may help to understand the role of the CEO in innovation. The systematic review of the literature was therefore extended to include a study of the role of the TMT in innovation in an attempt to find research data that yield insight into the effect of the immediate environment of the CEO. Several papers report on the role of the TMT in innovation and these mirror the studies conducted to assess the role of the CEO in innovation. For example, the impact of heterogeneity, prior experience, educational level and even team conflict on innovation has been studied and reported (Bantel and Jackson, 1989; Daellenbach et al., 1999; Lyon and Ferrier, 2002; Flood et al., 1997; Schoenecker et al., 1995; Camelo-Ordaz et al., 2005; Auh and Menguc, 2005; Wu et al., 2002; Srivastava and Lee, 2005; Elenkov and Manev, 2005; Kor, 2006; Patzelt et al., 2008; Talke et al., 2010). Only a small number of papers report research that introduced the CEO's direct environment as a factor influencing his/her impact on innovation. Kickul and Gundry (Kickul and Gundry, 2001) explored the degree of openness, the sharing of information, and idea generation promoted by the CEO within the TMT and the effect of these factors on innovation. Their study discloses how CEOs who use differences in background and perspectives within their TMT, are able to channel these differences into creative discussion and debate. The authors maintain that it is likely that the CEO's intention to foster creativity within the TMT encourages the adoption of several managerial practices, such as open, honest and supportive communication. Such management practices have been linked with innovation and other organizational outcomes in previous research (Oldham and Cummings, 1996; Amabile, 1998; Cummings and Oldham, 1997). Simsek (Simsek, 2007) showed that CEO tenure indirectly influenced performance through its direct influence on TMT risk-taking propensity and the firm's pursuit of entrepreneurial initiatives. Wu (Wu et al., 2002), surveying 198 industrial firms in Taiwan, found that board involvement in decisions made by CEOs resulted in an inverted U-shaped relationship with new product introduction performance and that board involvement was linked to a poorer performance of new product introductions in conditions of greater market instability. Finally, an inverted U-relationship was observed between social ties between the board and CEOs on the one hand and new product introduction performance on the other hand.

2.3.4 CEO roles

In the previous chapters the impact of CEO demographics and characteristics, of CEO leadership styles and the moderating role of context was discussed. Besides CEO characteristics and leadership, the systematic review of the literature also identified other factors which were used to explore the role of the CEO in innovation. For example, researchers tried to understand the impact of so-called 'singular' concepts such as attitude of the CEO towards innovation. Others explored the impact of attention of the CEO to his/her environment in driving innovational performance. Other role concepts such as commitment, involvement and innovativeness were also introduced in research.

The sections below offer an overview of the role descriptions used in the literature to study the role of the CEO (an exhaustive comparative study and an overview of the research papers in which these CEO role behaviors are used is included in Appendix D).

2.3.4.1 CEO attitude

According to Damanpour and Schneider (2006), a top executives' favorable attitude toward innovation facilitates the initiation of innovation by building feelings of confidence and providing support to organizational members for proposing new ideas' and 'facilitates adoption decision because strategic decision-makers with a more favorable attitude toward innovation would more likely decide to adopt innovative ideas'. Attitude has been linked to innovativeness (Bang Nam Jeon et al., 2006), risk propensity (Papadakis and Bourantas, 1998), perception (Rogers, 2003), functional specialization (Datta and Guthrie, 1994), tenure (Young et al., 2001), international work experience and flexibility (Kitchell, 1997) and age (Detienne and Koberg, 2002). The authors refer to 'attitude' in the context of innovation as a positional stance of the CEO towards change such that it impacts on the organizational climate and facilitates innovation (Ekvall, 1996; Hoffman and Hegarty, 1993; West and Anderson, 1996, Ekvall and Arvonen, 1991; Yukl, 2002; Damanpour, 1991; Dewar and Dutton, 1986; Hage and Dewar, 1973). Because the term attitude is defined as 'the state, condition or conjecture of a person, as likely to have a certain result' (Thatcher and McQueen, 1980), it is a 'positional' conception.

2.3.4.2 CEO attention

CEOs face competing claims on their attention. A scarce resource for many firms is no longer information but processing capacity to attend to information (Hambrick and Abrahamson, 1995; Hambrick and Mason, 1984; Smith and Tushman, 2005; Yadav et al., 2007). Attention is the chief bottleneck in organizational activity, and the bottleneck becomes narrower as we move to the top of organizations (Yadav et al., 2007). 'Attention' is defined as 'the act of keeping one's mind closely on something or the ability to do this; the mental concentration or mental readiness for such concentration' (Thatcher and McQueen, 1980). The focus of the CEO on the future and on the internal or external environment impacts the speed of detection and development of new technologies and explains why some top managers have a greater impact on innovation than others (Yadav et al., 2007). Kaplan and Kaplan et al. showed that CEO attention to an emerging technology is associated with the *subsequent* (italic by the authors) investment in its development (Kaplan et al. 2003; referenced in Yadav et al., 2007). Attention is a 'forward-looking' conception in that it collects data and information that may lead to investment decisions and focuses innovation.

2.3.4.3 CEO commitment

Commitment is 'the act of committing, or putting in charge, to entrust, to bind to a certain line of conduct' (Thatcher and McQueen, 1980). Managerial attention to building *supportive* systems and infrastructure is a critical step in enhancing innovation speed (Carbonell and Rodriguez, 2009). The long-range nature of technological innovation makes commitment important to the R&D organization (Starling, 1991). CEO commitment is made visible in a variety of ways: 'by acting as an executive sponsor,

helping a team to surmount obstacles, providing encouragement, maintaining open channels of communication, streamlining decision-making processes, and providing adequate capital and human resource' (Gupta and Wilemon, 1990; Smith and Reinertsen, 1992; cited by Carbonell and Rodriguez, 2009; Daellenbach et al., 1999). Commitment makes available appropriate funds and resources (Llorens et al., 2004; Cooper and Edgett, 2004; Swink, 2000; cited by Sanzo et al., 2012) and – thus - by accepting the risky nature of innovation projects (Menon et al., 1997; cited by Sanzo et al., 2012). Commitment is a 'facilitating' conception, in that it creates the financial and human circumstances for R&D to flourish.

2.3.4.4 CEO involvement

The act of involvement is 'to connect by way of natural result or consequence, to blend' (Thatcher and McQueen, 1980). This 'blending' is at the core of the concept of CEO involvement and presents the CEO as a participant in innovation. It requires the CEO to take a step beyond attitude, attention and commitment, as these roles may be played 'outside' of innovation, while the CEO who becomes involved in innovation requires his/her blending with the innovational discussions and his/her understanding of the underlying technology. On the one hand, there is rare involvement of top management in specific projects (Markham et al., 1991; cited by Green, 1995), but on the other hand, in small, high-growth design firms, CEOs were deeply involved in design decisions (Dickson et al., 1995). In the case of intranet adoption, CEO involvement appeared to be the only factor to impact innovation (Al-Qirim, 2007b). Laforet and Tann observed that in more innovative companies the CEO was found to be more involved in developing new products than in less innovative companies. Involvement is a 'knowledge based' conception as it requires prior knowledge in the field of R&D (Laforet and Tan, 2006).

2.3.4.5 CEO innovativeness

The term innovativeness is frequently used to describe the innovative character of an organization ('firm innovativeness' or 'corporate innovatineness') but it is rarely used to described the innovative behavior of a CEO. Thong and Yap and Al-Qirim have introduced the term 'CEO innovativeness' as the characteristic of a CEO as 'an entrepreneurial figure who is crucial in determining the innovative attitude of a small business'[11] (Thong and Yap, 1995; Al Qirim, 2007a). The entrepreneur is considered 'the central figure in successful technological innovation' and 'one who actively promotes the adoption of innovations' (Schon, 1963; Maidique, 1980, p. 72; Roberts, 1969, p. 259; cited by Lefebvre and Lefebvre, 1992). Thong and Yap describe 'CEO innovativeness' as a CEO who has original ideas, would sooner create something new than improve something existing and often risks doing things differently'. Among organizational, technological and environmental factors, CEO innovativeness is the only significant factor in the adoption of technological innovations (Al-Qirim, 2007b; Al-Qirim, 2007a). CEO innovativeness is an 'entrepreneurial' conception.

[11] Although these research papers use the term 'CEO innovativeness', they do not refer to the capability to think innovatively or the ability to come up with innovative ideas in the area of innovation but define it as a combination of involvement and attitude.

2.3.4.6 Discussion

The role descriptors presented above i.e. attitude, attention, commitment, involvement and innovativeness have been used in the literature to try to address the role of the CEO in innovation. The main disadvantage of these 'role descriptors' is that they have not been identified *as a result* of descriptive research but were proposed by management researchers as 'a priori' parameters. They are also poorly defined and contrasted and their further use in research is hampered by a lack of clarity. Nevertheless, they are potentially useful to conduct research because they allow the structure of findings obtained from conversations or interviews. It was therefore decided to define and contrast these terms. Table 2-2 summarizes these terms and offers a definition, a clear contrasting and an explanation of what they are not. They allow the description of an increasing impact of the CEO in the innovational environment: from a general *attitude* that allows innovation to take place, the CEO becomes *attentive* to future opportunities and defines a future for the company by directing and focusing the firm on these opportunities, is then willing to make formal resource *commitments* and then becomes *involved* in the intellectual discussions. At the end of the CEO innovation spectrum he/she is an *innovator* in his/her own right. The advantage of these role concepts is that – when clearly defined and contrasted – they can be used as 'research instruments' because they encompass a spectrum of roles that a CEO may be able to discharge in an environment of innovation.

	CEOs IN RESEARCH AND DEVELOPMENT – CONCEPTUAL ROLES FROM THE LITERATURE				
	Attitude	**Attention**	**Commitment**	**Involvement**	**Innovator**
Defintion (Thatcher and McQueen's Encyclopedia)	The state, condition or conjecture of a person , as likely to have a certain result	The noticing, encoding, interpreting and focusing of time and effort by organizational decisions makers (Ocasio, 1997). The act of keeping one's mind closely on something or the ability to do this; the mental concentration or mental readiness for such concentration	The act of committing, or putting in charge, to entrust, to bind to a certain line of conduct	To connect by way of natural result or consequence, to blend	To head and lead innovation in person disrupting the market with new products
	CEO attitude	**CEO attention**	**CEO commitment**	**CEO involvement**	**CEO innovator**
Literature definition	Studies in leadership posit a leadership behavior that is referred to as '*change –oriented*' behavior (Ekvall and Arvonen, 1991; Yukl, 1999) This leadership behavior refers to executives who: - present long-term perspectives - offers an appealing vision of the future - is receptive of new ideas - makes agreements with people inside and outside of the firm - in order to initiate and implement change from the current state of affairs This behavior is described as an '*attitude favoring innovation'* which 'facilitates the initiation of innovation by building feelings of confidence and providing support to organizational members for proposing new ideas' (Mumford, 2000). (cited by Damanpour and Schneider, 2006).	'Detection, development and deployment (of innovation) require the awareness of external opportunities and the anticipation of future events'. According to Yadav et al.(2007), *CEO attention* has a *temporal* and *spatial* component that increases this awareness. According to Yadav et al. the discretion CEOs exercise on *events that have yet to occur* or on events that *have a locus outside the company* , are predictive of a firm's innovative outcomes. 'When CEOs focus their attention on the future and on external entities, their communications and actions reflect this focus and serve to drive employees' attention to events and opportunities in the future and outside the firm' and '*CEO attention is a critical driver of innovation* '(Yadav etal., 2007).	CEO commitment refers to *the support that the CEO is willing to give to the new product development. It can be made* visible in a variety of ways (Gupta and Wilemon, 1990; Smith and Reinertsen, 1992): by acting as n executive sponsor, helping a team to surmount obstacles, providing encouragement of the team, maintaining open channels of communication with people involved in new product development, streamlining decision-making processes and providing adequate capital and human resources. It plays a positive role in accelerating innovation speed (Mabert etal., 1992; Emmanuelides, 1993; Kessler and Chakrabarthi, 1996) (cited by Carbonell and Rodrigueze-Escudero, 2009)	The CEO is involved in new product development (processes) – 'CEO involvement' is the degree by which the CEO takes final responsibility for making product design decisions, either alone or jointly (Dickson et al., 1995) and is personally involved in new product development (Laforet and Tann, 2006).	The CEO acts as the new product champion (Laforet and Tann, 2006), i.e. the new product is the 'CEO's product'. CEO innovativeness is characterized by an entrepreneurial perseverant CEO whose qualities as a transformational leader are the determinants of the overall management style of the business - it is the role of the CEO that determines the innovateveness of the business (Thong and Yap, 1995; Kitchel, 1997). The innovator CEO prefers solutions that change the structure in which a problems is embedded, in other words, solutions that have not been tried out and are therefore risky (Kirton, 1984, cited by Thong and Yap, 1995)

What it is	The CEO takes a positive stance towards innovation, creates an environment in which innovation can foster, presents a long-term vision for the firm, is receptive of new ideas in order to initiate and implement change for the better.	The CEO takes the time and effort to be informed about the potential of innovations in and outside the firm, scans the environment for opportunities, takes the time to learn about new product opportunities and customer needs and transforms these into a strategic vision. This attention is transformed in an innovative direction put forward by the CEO	The CEO commitment is the behavior by which R&D is taken forward by making available financial and human resources and by supporting underlying processes (communication, encouragement, decision-making etc.) to achieve these goals. A CEO may be formally, personally (and even passionately) committed to NPD but is not able to contribute technically or scientifically	The CEO is capable to take part in the innovational activities and the development of new products, i.e. the CEO is present during the technical discussions and contributes – a role he can discharge because oh his knowledge. He/she can do so at all levels, at all levels within the R&D function	Being an innovator in his/her own right, an individual who develops the ideas for new products, pushes these through the organization and acts as the new product champion. Examples: the iPad® is 'Steve Job's product'; the Airblade® is 'James Dyson's' hand dryer etc..
Key	**CEO -> develops a culture (that <u>drives</u> innovation)**	**CEO -> collects information (to <u>direct</u> R&D)**	**CEO -> offers resources (to <u>support</u> R&D)**	**CEO -> has relevant knowledge (to <u>discuss</u> R&D)**	**CEO-> is an innovator (and <u>develops</u> 'own' NPs)**
Nature	**Positional**	**Forward looking**	**Facilitating**	**Knowledge based**	**entrepreneurial**
What it is not	It is *not* a CEO who attempts to portray a positive and innovative image of his firm while concurrently preventing a culture of trust, discussion, openness, organizes his firm bureaucratically through strict procedures etc.	It does *not* mean that an attentive CEO should be either technically proficient or should become involved in R&D discussions. He can delegate all technical responsibilities to a CSO or CTO and focus on the market. He may be interested in new markets but may find the commitment (and associated risk) to invest in R&D too high.	It does *not* mean that a committed CEO has technical knowledge – this CEO can be fully committed to this firm and the R&D that can take place but needs an intermediary to bridge the gap between the business and the R&D function	It does *not* mean that the involved CEO is capable of conducting highly specialized lab experiments or perform development activities or is capable to act as an R&D team leader of a NPD project, but he/she is capable to engage in discussions at that level either in the lab or during meetings with specialists	
Context in which concept appears	Non-for profit public organizations, manufacturing firms, small IT firms	Communications technology, retail banking industry, electronics, financial services, home appliances, food and beverages, industrial equipment, lumber, construction, retailing, mining, manufacturing firms, machinery and metalworking firms	Manufacturing firms, food, chemicals, plastic, mechanical equipment, electrical equipment, transportation, large industrial R&D projects, office and residential furniture industry	Packaging design, small IT firms, manufacturing industry, high growth firms (no detail), IT e-business, small manufacturing firms	Information technology, manufacturing firms, small manufacturing firms, machinery and metalworking firms, small IT firms

Literat	• Damanpour and Schneider, 2006 • Thong and Yap, 1995 • Papadakis and Bourantas (1998)	• Yadav et al, 2007 • Eggers and Kaplan, 2009 • Makri and Scandura, 2010 • Miller & Toulouse, 1986a and 1986b • Kitchel, 1997 • Note : the term "attention" differs from the term "importance assigned to" used by Calantone et al., 1995 in which "attention" is given by the CEO to specific parts of the NPD process	• Carbonell & Rodriguez-Garcia, 2006 • Green, 1995 • Swink, 2000 • Calantone et al., 1995	• Dickson et al., 1995 • Laforet & Tann, 2006 • Bang et al. 2006 • Thong and Yap, 1995	• Kitchel, 1997 • Lefebvre & Lefebvre, 1992 • Harrison et al, 1997 • Laforet and Tann, 2006 • Thong and Yap, 1995

Table 2-2 CEO conceptual roles from the literature

2.3.5 Conclusion

The upper echelon theory offers an interesting perspective from which to study the role of the CEO in innovation because it starts from the premise that CEO decisions are at least partly driven by education, experience, demographics, values and beliefs which influence their interpretation of situations and impact their strategy formulation. This has led to a considerable literature the results of which may be characterized as 'granular' seen the variety of linkages studied between CEO characteristics and innovation. While upper echelon theory led to a wide variety of linkages between CEO characteristics and innovational output measures, the mere granularity of the research output prevents a generalized conclusion on the role of the CEO in innovation. Although the upper-echelons theory opened new perspectives in our understanding of the role of the top manager in innovation, it has not yet led to a better insight into the actual role of the CEO in innovation. That is why the proponents of the upper-echelons perspective were criticized for not directly studying strategic leadership behavior (Damanpour and Schneider, 2006; Cannella and Monroe, 1997; Boal and Hooijberg, 2000; Priem, 1990; DeTienne and Koberg, 2002; Markoczy, 1997; Young et al., 2001). Although there are research data on transformational leadership that point into the direction of an impact on innovation, there still remains uncertainty whether the impact of this leadership style, when used by a CEO, is capable to percolate through the organization into middle management levels to impact innovation. Although this cascading mechanism into the lower regions of the organization provides an interesting perspective, it is doubtful that the transformational effect is felt by knowledge workers in R&D, who are particularly unreceptive to management practices. The literature shows that the combined effect of CEO characteristics, transformational leadership style and context play an important role in the output of innovation. Accordingly, if demographics and leadership style are moderated by context, it can be argued that the role of the CEO in innovation is moderated by the presence of a R&D function and that a study of the role of the CEO in an environment of R&D needs to take into account the R&D function seen its strategic knowledge and autonomy and its rejection of managerial practices. Although the research that addresses the role of the CEO in innovation has offered some insight in the impact of CEO characteristics and leadership behavior on innovation, there is still a clear lack of knowledge on the *actual* roles that CEOs play in leading innovation. This is – in my opinion – due to the mainly quantitative research that was conducted to understand the role of the CEO. Doing so, researchers were capable to link parameters (eg. transformational leadership – innovation output) but were not able to determine what CEOs *do* to support or drive innovation.

2.4 Research gap

The literature review addresses 2 major topics. The first topic was the context and leadership of R&D (Section 2.2) explored to better understand a possible role of the CEO in innovation through a better understanding of the context of R&D. The role of the CEO seen from the angle of upper echelon and leadership theory, their relationship with context and roles played by the CEO constituted the second major topic (Section 2.3). What can be learned from the literature?

The first topic focused on the context of R&D and it was found that R&D team leaders play a role in innovation, by discharging roles such as product champion or boundary spanner. These roles can only be fulfilled by team leaders with intricate knowledge on the science of the firm's R&D. In other words, a similar role - such as product champion - is not available for the CEO, if he/she lacks the necessary knowledge to lead a team of scientists. Second, the effect of transformational leadership in the context of R&D is more pronounced in the early phases of research while it's effect is not pronounced during the later development phases. Third, the R&D function sees management practices and management interference as incompatible with effective R&D and therefore their receptivity for direction by the CEO may be minimal. Fourth, there is no data showing that there is upward influence of R&D to the CEO and for the CEO to effectively absorb R&D intelligence in his/her strategy formulation. In other words, the literature review of the context of R&D casts doubt on the role of the CEO and a study of his/her role should be conducted by exploring the role of the CEO through the perspective of R&D.

The second topic focused on theory, the research supporting the theory and the impact of context. Among these, upper echelon theory was given considerable attention and it was used to study the impact of CEO characteristics. These factors were weighed against contextual factors such as environment and firm characteristics but the impact of individual CEO characteristics (age etc.) as drivers or contributors to innovation is not clear. The literature also offers the transformational leadership theory as an approach to understanding the role and impact of the CEO. However, the arguments in favor of this theory in an innovational context are not based upon extensive empirical research into the effect of transformational CEOs on innovation. The lesson from the review of the literature is that the impact of transformational top management leadership on innovation is dubious. One can therefore not assume that such an impact on innovation exists through a transformational CEO who is separated from the R&D function by several hierarchical layers.

The literature also addressed singular concepts such as attitude, attention, commitment, involvement and innovativeness. It became clear that the CEO's attitude towards innovation is a more important innovation driver than age, firm tenure, educational background or work experience. These concepts may prove useful instruments to study the role of the CEO as compared with demographic or personality characteristics. Also, firms with the same underlying organizational orientations might move in different directions if the CEOs' attention to the future technologies differs. In other words, CEO attitude and attention are crucial factors that may impact innovation in a life science R&D firm. The literature review revealed the use of still other concepts besides CEO-attitude and -attention and they have been identified as CEO- commitment, -involvement and -innovativeness. The literature concepts can be categorized in hierarchical order, in which each level of the hierarchy constitutes an increased level of the impact of the role of the CEO in innovation. The hierarchical organization of the role is as follows: attitude -> attention -> commitment -> involvement -> innovativeness. The concepts describe an increasing role of the CEO in R&D, starting with a positive attitude, increasing to CEO attention to the future to identify opportunities, to commitment by

investing in financial and human resources, to actual involvement in the R&D discussion and finally by taking the helm as the innovator in the development of new products. These concepts offer an interesting alternative approach to the study of the role of the CEO because they focus on the role of the CEO rather than on his/her demographics. Until now these concepts have been used separately in different industrial settings (from manufacturing to IT and banking) and it is argued here that - seen their complementarity - they could be used together to study the role of the CEO in a qualitative research setting. Also, because the literature makes use of these concepts and has shown their importance and usefulness in describing the role of CEOs in innovation, but lack clear and differentiating definitions, this thesis proposes definitions for each of them to allow clear differentiation and use in qualitative research.

Table 2-3 below presents an overview of the research domains in the literature, ranging from upper echelon (1) and transformational theory (2) and the weighing of CEO leadership and context (1,2), to the impact of the top management team and the board (3) and the study of CEO role behaviors (4). It also shows that the research agenda whereby the role of the CEO in innovation was studied in the context of life science R&D and by combining the CEO role behaviors was not subject of research (5). It therefore constitutes a research gap. Also, the role of the CEO in innovation in R&D cannot be disconnected from the view of the R&D function on that role, seen R&D's strategic knowledge and potential impact on strategy formulation.

	Research topic - role of the CEO in innovation, explored through the lens of:	**Research reported in the literature**	**Life science R&D context**
1	Upper echelon theory + the impact of organizational and environmental impact	**√**	**-**
2	Transformational theory + the impact of organizational and environmental impact	**√**	**√**
3	The impact of the top management team and board	**√**	**-**
4	Singular concepts (attitude, attention, commitment, involvement, innovativeness) studied *separately* in *different* organizational contexts,	**√**	**-**
5	Singular concepts (attitude, attention, commitment, involvement, innovativeness) studied *together* in a *single* organizational context of life science R&D	**-**	**-**

Table 2-3 The research gap

However, there are still other observations that can be drawn from the literature and they address the methods that were used to conduct the research reported.

It was observed that three major research strategies were used and they are represented in box A, B and C in Figure 2-3. First, survey based research was used by upper echelon and transformational theory researchers in an attempt to develop prediction models (box A). These models attempted to answer the question whether a transformational leadership style of a CEO or the age of a CEO impacts innovation. Box B refers to the CEO research conducted by means of attitude, attention and other role conceptualizations used separately in different organizational contexts. Box C refers to the research strategy whereby either transformational theory or upper echelon theory

or role conceptualizations were used to understand the role of the CEO but excluding the R&D function, which is the locus of innovation 'par excellence'. The combination of boxes A, B and C therefore represents current research strategy. The same figure offers an alternative approach and they are represented in boxes A', B' and C':

- box A': in this research strategy, the quantitative survey based model - because it has not offered substantially better insight in the actual role of the CEO - is replaced by a qualitative approach in which the CEO is approached directly
- box B': in this research strategy, the role conceptualizations attitude, attention, commitment, involvement and innovativeness which were previously used *separately* in *different* contexts, are used *together* in a *single* context (for example in a life science R&D firm)
- box C': in this research strategy, the role of the CEO is investigated by involving the actors that form the locus of innovation - the R&D function - seen its peculiar character: high autonomy and limited receptivity for managerial leadership

The combination of approaches A', B' and C' constitute a new research strategy and is an alternative to the previous research strategy reported in the literature. By combining the observations of the review of the literature in Table 2-3 and in Figure 2-3 not only becomes the research gap visible from a content point of view but also from a methodology point of view.

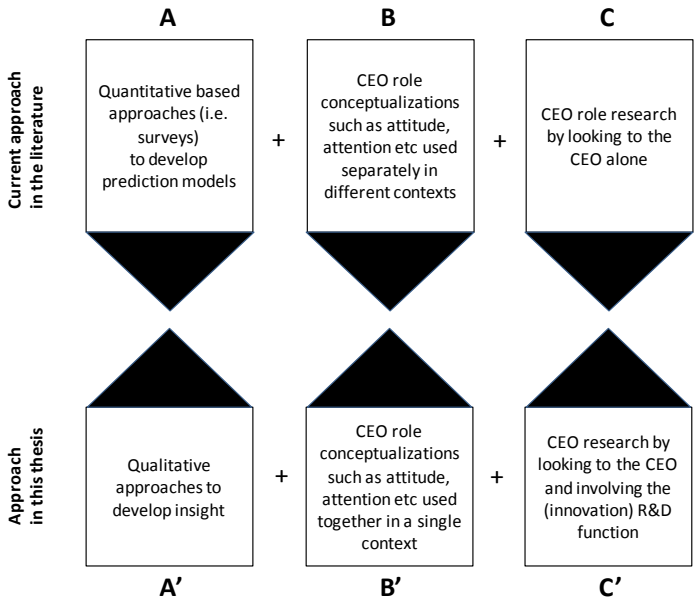

Figure 2-3 The proposed research strategy contrasted with established research strategies

It is therefore proposed that the study of the role of the CEO should proceed by going beyond the study of CEO characteristics (demographics or personality), their leadership and the search for predictive models, but should:

i. study the CEO directly by means of a qualitative approach (box A') and
ii. use a combination of role concepts of CEO attitude, -attention,-commitment, -involvement and –innovativeness in a single context of life science R&D firms (box B') and
iii. involve the R&D function to inquire how it perceives the role of the CEO (box C')

This approach is entirely descriptive in nature as it attempts to answer the question what the CEO is actually doing to overcome the challenges of complex life science innovation. It assumes a direct interaction with the CEO and his/her R&D function. By taking this approach, it is aimed to obtain a better insight into the *actual* role of the CEO in innovation in the context of life science R&D firms.

2.5 Summary

A systematic review of the literature on the role of the CEO in innovation and a bifocal review of the literature reveals that research on the role of CEOs in innovation primarily used survey-based approaches employing upper echelon or transformational leadership theory. Using the upper echelon perspective, CEO demographics such as age, tenure and/or background were used as explanatory and predictive factors of the role of the CEO. Alternatively, a leadership-based perspective was used to explore the relationship between CEO transformational leadership and firm innovation but both perspectives have not further elucidated the actual role discharged by CEOs in innovation. The review also revealed research in which CEO behaviors such as attitude, attention, commitment, involvement and innovativeness were used to explore the role of the CEO. They describe an increasing role of the CEO in R&D, starting with a positive attitude towards innovation, to attention to the future, to commitment by making available financial and human resources, to involvement in R&D and finally to innovativeness in which the CEO takes the helm in the development of innovative new products. They are potentially better suited to explore the role of the CEO in innovation, because they reflect CEO behaviors instead of CEO demographics. A problem however with the use of these concepts is that they are not well defined, were used separately in survey-based studies and explored in different industrial settings. The literature was therefore explored further and a clear definition is proposed that contrast these concepts accurately such that they can be used in further research. A research gap was identified that addresses as well the content as the research strategy.

2.6 Conclusion

The question what CEOs do to lead innovation in life science R&D firms remain unanswered in the literature. Answering this question will be difficult when researchers remain focused on quantitative survey-based research because the *actual* role will remain 'undiscovered' or may only be inferred or assumed from the relationships detected between predetermined variables (e.g. transformational leadership behavior of the CEO and firm innovation) or from the identification of (leadership or demographic) factors that may or may not impact innovation. What individuals *actually do* can only become known if these individuals are asked *what they do*. In other words, successful research of what CEOs do to lead innovation and how they are capable to do

so, should result in a clear role *description*. How this can be achieved is discussed in the next chapter.

3 Research design

3.1 Introduction

The literature review pointed to a research gap that consists of both a research topic and a research methodology. It became clear that little is known about the actual role of the CEO in innovation in life science R&D firms and that a qualitative study of the role of the CEO in innovation has not yet been conducted. Therefore there is no research data in the literature that looks for confirmation and the research topic lends itself to exploration. This chapter proceeds as follows. First, it offers arguments to support the proposition that the proposed research project is exploratory in nature rather than confirmatory (Section 3.2). This distinction is crucial because it impacts the chosen methodology and methods (Section 3.3.). The theoretical perspective from which this research is conducted is presented in Section 3.4. The research questions and procedures are presented in Section 3.5. and Section 3.6 summarizes the chapter.

3.2 Exploratory research

3.2.1 Defining exploration

Much of the understanding of the concept of exploration stems from Stebbins' treatise on exploratory research in the social sciences (Stebbins, 2001). The term 'exploration' seems to have entered qualitative social research through Glaser and Strauss's seminal volume *The Discovery of Grounded Theory* (Glaser and Strauss, 1967). According to Stebbins, exploration can be defined in different ways, based as it is, on the verb '*to explore'* (Stebbins, 2001, p2). Exploration means:

- 'to study, examine, analyze or investigate something, i.e. investigative exploration
- to become familiar with something by testing it or experimenting with it, i.e. innovative exploration
- to travel through a particular space for the purpose of discovery and adventure, i.e. exploration for discovery
- to examine a thing or idea for diagnostic purposes, whilst the explorer realizing what he/she is looking for, i.e. limited exploration'

Stebbins, building upon a previous proposal by Vogt (1999), defines exploratory research in the social sciences as follows:

> 'Social science exploration is a broad-ranging, purposive, systematic, prearranged undertaking designed to maximize the discovery of generalizations leading to description and understanding of an era of social or psychological life. Such exploration is, depending on the standpoint taken, a distinctive way of conducting science – a scientific process – a special methodological approach (as contrasted with confirmation), and a pervasive personal orientation of the explorer. The emergent generalizations are many and varied; they include the descriptive facts, folk concepts, cultural artifacts, structural arrangements, social processes, and beliefs and belief systems normally found there'

3.2.2 Arguments for exploration

There are complementary reasons why this research is to be defined as exploratory in nature. The reasons are given by Stebbins (2001) who describes researchers as explorers when:

> '*they have little or no scientific knowledge about the group, process, activity or situation they want to examine but nevertheless have reason to believe it contains elements worth discovering*'

and by Karlsson (2009) who argues that:

> *'With little to base the theoretical development on, the study will by necessity take on an explorative character. Hence early phase research will often be explorative'*

There is little or no scientific knowledge available about the role of the CEO in innovation, except for some linkages between CEO demographics (age, gender etc) and innovational output. However, the *actual* role of the CEO in the process of innovation remains largely unexplored. Also, the investigation of the role of the CEO in innovation – although not a new research topic, as we have seen in the literature review – has addressed this role only by looking into the effect of so-called 'CEO-proxies' such as pay, education or experience. No empirical study was identified in the literature that approached the CEOs individually in an attempt to gain insight into what they consider to be their role and how they fulfill it. The reason for this absence of empirical studies may lie in the fact that CEOs are particularly difficult to approach seen their extraordinary time pressure which prevents them to become actively involved in academic research projects (Yadav et al., 2007). Also, there is no scientific knowledge retrieved from the CEO's interaction with the R&D function and its potential impact on innovation. In other words, based upon the outcome of the literature review, there is still 'reason to believe it contains elements worth discovering'.

According to Stebbins (2001), there are three conditions under which exploration is the preferred approach:

- when the unit of analysis (the group, the process, the activity or situation) has received little or no systematic empirical scrutiny
- when the unit of analysis has been largely examined using prediction and control rather than flexibility and open-mindedness
- when the unit of analysis has grown to maturity along a continuum that reaches from early exploration to full qualitative and quantitative confirmatory studies but has changed so much along the path of investigation, it 'begs to be explored anew'.

In view of the proposed research project these conditions are met.

First, until now the CEO's point of view and what he/she considers to be his/her role, have not received attention from management researchers. As stated above, the CEO him/herself has received little or no systematic empirical attention.

Second, until now the role of the CEO in innovation was investigated by means of variables that would predict changes in innovation as a result of variation of age, tenure, education. The literature review has shown that the research was conducted in order to generate predictive parameters. For example, if the CEO is old, will this drive or hamper innovation?

Or, if the CEO has an engineering background will this reflect in the way a new manufacturing plant is organized?

Third, the results of the studies that have been conducted are not corroborative, even contradictory and still have not been able to fully assess the role of the CEO. This stage of 'mature' research has not been reached in the field of CEOs and innovation and therefore does not apply. In other words, the topic still 'begs itself for exploration'".

Also, according to Yin, the fact that a research question focuses mainly on the 'what' instead of the 'why' of a phenomenon, offers a justifiable rationale for conducting an *exploratory* study, the goal being to develop pertinent hypotheses and propositions for further study (Yin, 2009; p9).

Therefore the conclusion can be drawn that the research into the role of the CEO in innovation can be categorized as exploratory in nature.

3.2.3 Goals of exploration

Exploration aims to generate new ideas and 'weave them together to form grounded theory, or theory that emerges from data' (Stebbin, 2001) while the outcome of exploration is 'inductively derived generalizations about the group, process, activity or situation under study' (Glauser and Strauss, 1967; Stebbins, 2001). In simpler terms: the explorer searches for generalizations leading to detailed and profound understanding of the group, the process, or activity under study.

3.2.4 Studying elites

Exploratory studies can be done in different settings and under different contexts, but the investigative efforts needed to explore elites such as top-politicians, movie stars, high level army commanders ask for specific sensitivities. Hertz and Imber have addressed the research peculiarities when studying elites by informing the potential elite-researchers as follows (Hertz and Imber, 1995; Zuckerman, 1972) :

- if at all possible, study the elites directly and do not engage in exploring public records as these are vastly insufficient to study these individuals, because they may offer a "glossy" description of the role of the elite
- each research approach requires a specific strategy and there is no general elite-study-methodology
- it may be worthwhile to combine several approaches such as surveys and interviews if possible
- acquire information from within the firm and not from outside sources
- use the executive's own network for approaching him/her
- investigate in depth as the information required to address the research question may be hidden
- listen carefully when the elites describe their worlds

In other words, an 'elite-explorer' should

- be careful using data which are external to the firm
- approach the role of the CEO from within the firm

- use several research methods if possible
- inquire deeply into the information offered
- connect to other CEOs by means of the CEO's network.

In addition, Kvale and Brinkmann argue that '… elites are being used to being asked about their opinions and thoughts, and an interviewer with some expertise concerning the interview topic may provide for an interesting conversation partner. The interviewer should be knowledgeable about the topic of concern and master the technical language' (Kvale and Brinkman, 2009). One point of caution that is offered by Kvale and Brinkman is that experts could have their 'talk tracks' ready for any interview and the interviewer should 'require considerable skill to get beyond'. One way of reducing this trap is to involve an interviewer who is skilled enough to go through the obvious glossiness that may appear and the 'pep-talk' that the elite may offer. A thorough understanding of the pipeline of their products and technologies therefore is necessary to convince the interviewed CEO that the researching interviewer is sufficiently skilled to understand the arguments and go behind the 'obvious talk'.

3.2.5 Rigor in exploratory research

A key contribution to the topic of rigor in exploratory social research is given by Stebbins who offers a full and detailed overview of its implications (Stebbins, 2001).

Stebbins argues that in the case of exploratory research projects, a clear research framework may still be in an embryonic phase: logical argumentation therefore is required but does not follow a pre-established framework, whereby pattern matching is difficult to achieve as previously established or predicted patterns are hardly available. In addition, theory triangulation, whereby findings and conclusions can be supported by different theoretical frameworks is difficult if not impossible to achieve in case of exploration. Internal validity therefore will need to be achieved by strong internal logical argumentation. Construct validity, referring to the 'extent to which a study investigates what it claims to investigate' can be achieved by a clear chain of evidence reconstructing the path from initial research question to final conclusion and by means of triangulation strategies, if at all possible. In addition to strong internal logical argumentation, rigor in exploratory research can be strengthened by using research instruments that are clearly defined.

Therefore the concepts that were identified in the literature, i.e. attitude, attention, commitment, involvement and innovativeness have been assigned clear definitions such that they can be used in research projects to validate the findings of previous studies.

3.2.5.1. Addressing the validity of the research

Validity refers in ordinary language to the truth, the correctness and the strength of the statement (Kvale and Brinkman, 2009). Generalizations are the exploratory study's 'raison d'être' and the 'principle of supremacy of generalization should also guide the structure of the report' adding that 'generalizations are rarely simple and straightforward: they must usually be qualified, put into context and related to other generalizations' (Stebbins, 2001). However, generalization may impede true understanding: 'properties shared by all organizations are superficial, obvious or unimportant' (Harrison, 2002; p161). Therefore, the issue of generalization should be 'contextualized' in that the observations made during a

research project can be generalizable to the specific context under which the exploration took place and the need for concatenation as argued by Stebbins (Stebbins, 2001).

Validity in exploratory studies refers to the way a researcher is capable of gaining an accurate or true impression of the group, process, or activity under study and how this can be accomplished. Validity refers to the question whether the data that are proposed as a result of an exploratory study can be considered credible and valid. Stebbins argues that validity in exploratory research

> 'concerns with the explorer's capacity to acquire directly an accurate impression of a group, process, activity or situation ... and is more easily resolved , for example, by asking key informants to comment on the familiarity and reasonableness of observations and finding recurrent evidence for each generalization' (Stebbins, 2001; p26)

Validity in exploratory research is difficult for three reasons:

- reactive effects of the observer's presence or activities in the phenomenon being observed
- distorting effects of selective perception and interpretation on the observer's part
- limitations on the observer's ability to witness all relevant aspects of the phenomena in question

Especially the second element is worrisome for the exploratory researcher 'because of the heavy subjective element involved when a lone researcher (the usual way exploration is conducted) observes and interviews' (Stebbins, 2001; p48). Exploratory researchers, therefore, should increase the validity of their research in three ways:

- by discussing the generalizations with the people they are investigating to determine if these ideas 'have a familiar ring', in other words that they are considered plausible in the eyes of the respondents: i.e. the plausibility of the observations
- by looking 'assiduously' for evidence that might contradict the observations as the observer is aware of potential bias in his research and that they are not held with 'great unbending conviction'; i.e. the removal of bias
- by asking themselves whether there is a sufficient number of occurrences of an event or process to 'constitute grounds for a valid generalization', i.e. the grounds for generalizations

These three concerns were addressed in this research as follows:

- plausibility of the observations: this is achieved by presenting the outcome of the research interviews with the individual CEOs to the focus CEO group and by checking the CEO interview observations with the R&D managers
- the removal of bias: the awareness of bias is specifically addresses by checking the CEO arguments against those of the R&D managers, i.e. do R&D managers support the arguments made by the CEos therebut preventing a potentially biased observations on the part of the interviewer
- the grounds for a valid generalization, was achieved by taking Krippendrof's approach in that themes are collected and their frequency counted in order to obtain insight in

the weight by which themes and subthemes emerge (Krippendrof, 2013). Therefore, the theme emergence was also weighed, taking into account that the evaluation of qualitative data using quantitative data should be done with utmost caution (Krippendorff, 2013).

Exploratory researchers should do their best to ensure it (validity), recognizing however that their efforts in this regard for any single study will be only partially successful and that they will have to wait for future explorations before the tale of validity is fully told' (Stebbins, 2001; p49). Finally, 'validity in exploration is linked to representativeness of the sample of groups, processes, or activities being examined' and 'it will be strongest when hypothetical generalizations emerge from direct empirical study of a set of representative instances' (Stebbins, 2001; p26).

3.2.5.2. Addressing reliability

Reliability demonstrates that

> 'the operation of a study – such as the data collection procedures – can be repeated with the same results. It is usually impossible to repeat data collection exactly, because the conditions have changed. But demonstrating that you have detailed evidence available (for example, taped interviews, transcript and coding) and that you have analyzed the data in a systematic way that others could repeat is a key reliability test' (Partington, 2002).

In other words, reliability pertains to 'the consistency and trustworthiness of research data; it is often treated in relation to whether a finding is reproducible at other times and by other researchers (Kvale and Brinkman, 2009). In case of exploratory research, 'reliability' refers to the replication of the findings of a researcher and asks the question whether the same data will be obtained if the exploratory study would have been conducted by another researcher (Stebbins, 2001).

Reliability is linked to the representativeness of a sample because the data obtained from a representative sample include instances of all relevant factors such as a sample of firms within a given range of size either by turnover, R&D expenses, number of employees, R&D activities or organizational structure and culture.

The reliability of the approach is also addressed by adhering to a strict procedural process that is described in detail in Appendix E, J and L of the thesis. Reliability in interview based research, according to Kvale (Kvale, 2009) pertains to 'the consistency and trustworthiness of research findings and ... to the issue of whether a finding is reproducible at other times and by other researchers'. During the conduct of this research great care was given to the development of and adherence to procedures that could be repeated by other researchers in order to increase the reliability of the data. Reliability of the research data was achieved through the following steps described in detail in the table below (Table 3-1).

Action to increase reliability:	Impact on research
Detailed description of the development of the research questions for both CEO and R&D executives and a detailed description of the translation of research questions into interview questions using the pentathlon innovation framework (Goffin and Mitchell, 2011; Appendix E)	To allow the repeatability of the approach used by other researchers when attempting to interview CEOs and R&D executives by offering a set of interview questions based on previous research on innovation
Establishment of a procedure for the selection of firms and of the approach of each CEO or R&D executive (see Appendix E)	To allow identical approaches in identifying firms and approaching each individual CEO and R&D executive
Detailed procedure for the re-analysis of the interview transcripts after the last interview transcript was analyzed and themes were identified (see Appendix E, J and L)	To ascertain that a/ each transcript was a trustworthy replication of the interview and to ascertain that the information collected through the interviews is identifiable by other researchers and that b/ each transcript is analyzed in exactly identical conditions
Development of detailed theme definitions based upon an extensive literature review and analysis (see Chapter 2 and Appendix D)	To allow other researchers to use identical themes for the analysis of transcripts of CEO and R&D interviews

Table 3-1 Reliability enhancing actions

3.3 Methodological fit

This research project meets the requirements of an exploratory research project for the following reasons. The unit of analysis (the CEO) has received little or no systematic empirical scrutiny, it has been largely examined using prediction and control rather than open-mindedness and it 'begs to be explored anew'. The fact that this research project is of an exploratory nature has consequences with respect to the issue of validity and reliability as was discussed above, but also upon the research methodology as will be discussed below.

As this research is exploratory in nature, it is necessary to define the type of methodology that is most appropriate for an exploratory research project. Stebbins observes that:

> 'Exploration is no place for data collection formulas distilled from conventional theory and methodological practice. On the contrary, exploration is where the art of science is most widely exercised, the art of science where imagination reigns freely. Creativity in this domain comes through inductive reasoning, as researchers discover order in what initially appeared to them as chaos'

The question however is whether the exploratory nature of our research project permits the use of any methodological approach that suits the purpose. It was Edmondson and McManus who argued that 'compared to experimental studies, analyses of published data sets, or computer simulations, achieving fit between the type of data collected in and the theoretical contribution of a given field research project is a dynamic and challenging process' and have therefore introduced 'a framework for assessing and promoting methodological fit as an overarching criterion for ensuring quality field research' (Edmondson and McManus, 2007). As Stebbins has focused particularly on exploratory research we will investigate

methodological fit in exploratory research from the viewpoint of exploratory researchers such as Stebbins. However, it is appropriate to look for methodological fit from the other angle, whereby the starting point is not the exploratory nature of the project but a more general framework from which methodological fit can be derived, such as the approach presented by Edmondson and McManus. First, Stebbin's view on exploratory methodology will be discussed followed by Edmundson and McManus' approach.

3.3.1 Exploratory research

As it was argued that the proposed research is of an exploratory nature, the next question is which research methodology is appropriate. As stated above, exploration aims to generate 'inductively derived generalizations about the group, process, activity or situation under study' (Glauser and Strauss, 1967; Stebbins, 2001). According to Stebbins (Stebbins, 2001; p1), the concept of exploratory research in the social sciences is 'usually mentioned, if at all, only in passing, in Glaser and Strauss's *The Discovery of Grounded Theory* (1967): Exploration aims to generate new ideas and weave them together to form grounded theory, or theory that emerges directly from data' (Glaser and Strauss, 1967, referenced in Stebbins, 2001; p9). Harrison presents a matrix of research strategies that allow a fit between the researcher's style and the phenomenon under study (Harrison, 2002; p170). The researcher's style can be categorized between two extremes, ranging from structured to unstructured while the context of the phenomenon can range between fixed in time and dynamic in nature. Researching a fixed phenomenon can be either structured by means of a fixed route map or via an unstructured, rather exploratory route. The researcher with a preference for unstructured methods such as grounded theory would for example address a fixed phenomenon – such as the role of the CEO in innovation – in a heuristic way or, as Harrison puts it: 'the phenomenon exists but the researcher adapts the method to the context'. In addition, 'these ideas (generated through exploratory research) are the raison d'être of the enterprise, and everything else – study design, measurement techniques – is subordinate to them' and 'a (social science) explorer is first and foremost a theorist' while 'theory is the primary goal of exploratory research and that grounded data are only a means to this end…' (Stebbins, 2001; p9 and p51).

As was stated earlier, Stebbins (2001) offered three conditions under which an exploratory approach is justified, especially when the unit of analysis has received little or no systematic empirical scrutiny, has been largely examined using prediction and control and begs to be explored anew. It was argued above, that the research into the role of the CEO in innovation complies with these requirements. From this point of view, a grounded theory approach is justified as it would start to generate knowledge ground up, to generate new ideas and generalizations. Therefore, at first sight and seen the exploratory nature of the research, a grounded theory approach seems to be an appropriate strategy as it allows the explorer to be free and unrestricted in view of the data to be collected. However, the discussion on the methodology needs to be taken a step further.

The grounded theory method relies on continuous comparison of data and theory beginning with data collection and emphasizes the emergence of theoretical categories *solely from evidence* and an incremental approach to case selection and data gathering (Eisenhardt, 1989). A grounded theory approach was already used in the area of innovation and CEO-research. For example, some researchers used grounded theory approaches in exploring innovation networks and the role of CEOs in change (Hargadon and Sutton, 2000; Gioia and

Chittipeddi, 1991). In grounded theory, 'all the codes are discovered in the data (or developed from the data) in the sense that the coding is grounded in the data'. A grounded theory approach is therefore justified in view of an exploratory nature of a research project that is new and examined for the first time, which is the essence of exploration (Glauser and Strauss, 1967; Stebbins, 2001).

The above argument however is justified when prior knowledge on the topic would be minimal or non-existing and when it would explore the world of the CEO in innovation 'ground up' as if no prior empirical or conceptual knowledge was available. However this is not the case. In the section on the literature review, five concepts were identified which were based on empirical studies on the impact of CEOs in innovation: CEO attitude, CEO attention, CEO commitment, CEO involvement and CEO innovativeness. In other words the research does not – cannot – start 'ground up', unless a deliberate neglect of all previous research data and conclusions would be assumed. This is not only a difficult psychological stance from the explorer's point of view but can also be considered inappropriate as it can hardly be justified to neglect previous research. Therefore, a grounded theory approach – although compatible with an exploratory mindset and attractive in its own right – is difficult to justify.

Therefore, a methodology needs to be identified that is

- compatible with the exploratory state of mind,
- takes into account previous research and the concepts developed,
- allows an interview based approach as we will address the CEOs directly,
- is capable to develop ideas from which to build hypothesis or generalizations and is
- specifically developed to study the phenomenon within its context

These parameters for selection are discussed.

Compatibility with the exploratory state of mind. The methodology should allow for a focused topic of conversation which is determined in advance and for the collection of reactions and interpretations in a relatively open form. This requires a methodology that allows a conversation to take place that allows the parties to have an 'inter-view' and the free exchange of ideas (Kvale and Brinkmann, 2009).

Account of previous research and the developed concepts. The methodology should be open for the introduction of concepts or categories which have been developed previously either through a literature review of via empirical or conceptual studies. In other words, it should be open for the introduction of a priori categories and theoretical frameworks in which to discuss and interpret the data.

An interview based approach. In view of the nature of the unit of analysis (the CEO), it is imperative that we take into account the limitations posed upon our research by the poor availability of top managers for these type of studies (Yadav et al., 2007). One may consider methodologies such as ethnographic studies but should realize that this puts a heavy burden on the agenda of CEOs and it is not clear whether these individuals are open to the presence of an individual that may potentially be 'contaminated' with highly confidential company information. From a viewpoint of the exploratory nature of the study it is argued that the selected methodology should be compatible with a focused interview of limited duration.

Capability to develop ideas from which to build hypotheses or generalizations. The methodology should allow for the building of theory from which to develop hypotheses or propositions that can be tested in a follow-up research project.

Methods that are specifically developed in view of the context. As the goal of the research project is to better understand a real-life phenomenon, realizing that such an understanding encompasses important contextual conditions which are highly pertinent to the phenomenon of study, the methodology should – by definition – allow the phenomenon-context relationship.

3.3.2 Methodological fit in management field research

Edmondson and McManus developed an approach that addresses the methodological fit in management field research (Edmondson and McManus, 2007). They define methodological fit as 'an internal consistency among elements of a research project'. They offer four key elements of field research: research question, prior work, research design and contribution to literature. According to Edmondson and McManus, 'producing methodological fit depends on the state of relevant theory at the time the research is designed and executed' because 'it (the relevant theory) serves as a given, reasonably fixed context in which new research is developed: it is the one element over which the researcher has no control (i.e. the state of extant theoretical development cannot be modified to fit the current research project)'.

Edmondson and McManus propose a 'continuum of theory' that may drive methodological fit considerations. This continuum ranges from nascent theory over intermediate theory to mature theory and is presented in Figure 3-1 below.

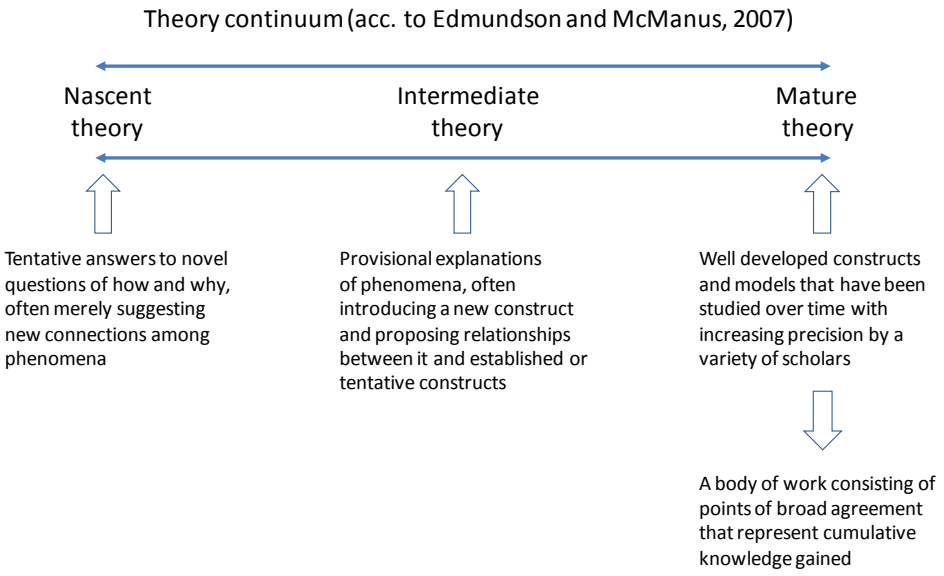

Figure 3-1 Theory continuum

As was already argued above, in the case of this research, there is no solid argument to state that this research is taking place in an environment of mature or even intermediate theory. The literature review has shown that tentative theoretical concepts have been developed to describe the role of a CEO in high tech ventures (Makri and Scandura, 2010). As Jung et al. argue, transformational theory has not yet shown its value to better understand the role of a CEO in innovation (Jung et al., 2008). Also, the upper echelon theory was criticized for the use

of proxies such as CEO-age and CEO-tenure, as an explanatory and predictive factor for the role of the CEO in innovation (Boal and Hooijberg, 2000; Priem, 1990). Finally, Arendt's model in strategic decision making is a useful but tentative starting point for addressing the role of CEOs in innovation, but again cannot reach the status of a mature theory as no empirical studies have underpinned the proposed model (Arendt et al., 2005).

Therefore, it can be argued that the theoretical environment is not mature but nascent. According to Edmondson and McManus, in studies where theory is nascent or immature, researchers do not know what issues may emerge from the data and so avoid hypothesizing specific relationships between variables and because the theory is nascent and not much is known about the field or area of research, there is a need for 'rich, detailed and evocative data' to 'shed light on the phenomenon' (Edmondson and McManus, 2007). Edmondson and McManus therefore propose the use of interviews, observations, open-ended questions and longitudinal investigations as they are considered methods of learning with an open mind. This can happen through the use of ethnographic approaches or through 'more simply exploratory interviews with organizational informants'. Edmondson and McManus therefore propose the grounded theory approach as was already discussed above and which is – although compatible with an exploratory mindset and attractive in its own right – difficult to justify. In order to allow a justified selection of a methodology, Edmondson and McManus reviewed research projects that were conducted under the 'nascent theory' approach and observed that these explorative studies collected qualitative longitudinal data that were obtained through the use of open-ended interviews, observations of meetings, review of archival qualitative data, observation of all group meetings and conversations. Data analysis took the form of iterative, exploratory content analysis.

The approach proposed by Edmondson and McManus asks for the collection of data retrieved from interviews, observations of meetings, archival qualitative data and observation of group meetings etc. It assumes an approach that encompasses a large variety of variables. As the approach in investigating the role of the CEO in innovation consists of directly approaching CEOs and inquiring about their role in innovation, each CEO becomes a suitable case for investigation. It is therefore logical that the approach consists in taking a number of 'cases' and investigate them in great detail. The obvious question therefore is whether the case study approach is an appropriate methodological research strategy.

3.3.3 Case study research and its limitations for our research

As argued by Yin in his treatise on the selection on the method of investigation, in an exploratory study any of the existing and acceptable methodologies could be used, ranging from an experiment, through survey, archival and /or historical analysis and case study (Yin, 2009; p9). The fundamental argument used by Yin for the selection of a case study is when the context of the research topic is of importance:

> 'when one wants to understand a real-life phenomenon in depth, but such understanding encompasses important contextual conditions and because they are highly pertinent to your phenomenon of study'

In addition, the case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon not at all understood (Karlsson, 2009; Eisenhardt, 1989). In this research project the goal is to investigate the role of the CEO in the

specific context of science-based innovation (R&D), a context that is substantially different from those in which innovation is not separated from the other activities and functions in a firm but – on the contrary - constitutes a highly-specialized and bounded knowledge base of people, equipment, procedures, language, routines and output .

According to Harrison, case study research is of particular value where the theory is comparatively weak and the environment under study is messy (Harrison, 2002). These comments are of relevance in our research for the following reason.

Firstly, the proponents of the upper echelon theory were criticized for not directly studying the strategic leadership behavior because, in spite of the new perspectives that it opened in the understanding of the role of top managers in innovation, it was primarily used to study the influence of demographic variables to predict the behavior of top managers. However, top managers and their roles in innovation, remained out of focus.

Secondly, others have used other perspectives to try to explain the CEO's behavior in innovation by focusing on the leadership style (Jung et al., 2008) or by introducing new perspectives such as the creative and operational leadership concepts (Makri and Scandura, 2010). Still others have explored compensation (agency theory) to explain the CEOs behavior in innovation.

Thirdly, the studies to understand the role of the CEO were conducted in very different industrial settings, varying from small and medium-sized companies to major corporations, from governmental to private organizations, and within very different fields of innovational settings ranging from electronics to manufacturing to banking. Some studies explored the role of the CEO in innovational R&D assuming that the R&D environment in one context (e.g. the IT industry) is managed according to the same principles and risk ratios as in another context (such as in the life science R&D industry). This resulted in generalized propositions about the role of the CEO in innovation which hardly took into account the specific context (Harrison, 2002, p161).

One of the advantages of a case study, and of particular importance in our case, is that it is essential to draw a boundary around a study, whereby the circumstances under which the conclusions apply will be apparent (Harrison, 2002, p158).

In addition, field based research can narrow the gap between practice and research because it takes the researcher to the field for dialogue and observation (Harrison, 2002; p.163). According to Harrison, case study research is actually an envelope for several possible research methods and structured interviews, field studies and surveys are all possible methods which can be deployed under the case study banner (Harrison, 2002, p. 164). A case study, according to Yin, is an 'empirical inquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident' (Yin, 2009). Finally, case studies are considered appropriate tools in the critical, early phases of a new management theory, when key variables and their relationships are being explored (Yin, 2009; Eisenhardt, 1989).

However, caution is required in view of a possible use of the case study approach, as it implies the collection of a variety of research data such as archival data, meeting minutes, research reports and even reporting of R&D meetings. There is no guarantee that CEOs who – for

example – would be willing to be interviewed, would also accept to make available archival data (agendas, R&D meeting minutes etc) for research purposes. Therefore, there is need for caution in selecting a case study approach and it was decided that in a first stage, the research project would consist of interviews, realizing that when trust and respect developed between the interviewer and the interviewee (the CEO) there would be a point in time when these archival data would be made available and a full case study approach can be undertaken.

It became clear as from the first interviews, that CEOs were not prepared to make their agendas, meeting minutes and reports available for research purposes and therefore the case study approach was not selected. Therefore, it was decided to conduct this research entirely based on research interviews.

3.3.4 Exploratory descriptive research

Although it is argued that the research presented is of an exploratory nature, seen the limited prior knowledge of the actual role of the CEO in innovation, the use of research interviews leads the qualitative interviewer to

> 'encourage the subject to describe as precisely as possible what they experience and feel, and how they act. The focus of the interview therefore is on descriptions that depict the differences and varieties of the phenomenon' (Kvale, 2009).

Descriptive research is used to describe characteristics of a phenomenon. Descriptive research generally precedes explanatory and confirmatory research. Exploratory descriptive research does not answer questions about how/when/why the characteristics occurred but rather addresses the "what" question' (Shields and Rangarajan, 2013). Shields and Rangarajan offer the example of the periodic table of elements. The table is now taken for granted by every chemist, but it took descriptive research by Mendeljev to construct it. For example, over time the periodic table's description of the elements allowed scientists to explain chemical reactions and make sound predictions of what would happen if the elements described in the table were combined. Hence, the exploratory research in this thesis is not used to look for causative factors within the observed phenomenon (although it does not prevent the development of hypotheses for future research). Therefore exploratory research often has the aim of description and researchers may follow-up with examinations of why the observations exist and what the implications of the findings are. Another example comes from Sheard and Kakabadse's study on the extent to which a role based perspective can provide insight into a networked form of leadership. They selected a number of individuals drawn from senior management teams and by means of descriptive research they were able to identify the actions, attitudes and beliefs of the senior managers, in view of their relationships within the firm's managerial network (Shear and Kakabadse, 2007). In addition, Loch et al. (2007) use an interview based investigation to describe how top managers manage projects that they have difficulties understanding.

In analogy, our research will need to result in a clear role description of the CEO. Instead of trying to find linkages between parameters (leadership behaviors, firm innovation output), this research specifically wants to show what CEOs do when they take responsibility and accountability for innovation in life science R&D firms.

3.3.5 Conclusion

Quantitative (survey based) research is not an attractive approach to study the role of the CEO in innovation, because it has shown not to offer a better insight into the *actual* role of the CEO in innovation, let alone in the context of life science R&D. Therefore the decision was taken to address the research topic using an exploratory qualitative approach. Although compatible with an exploratory mindset and attractive in its own right, a grounded theory approach is not an appropriate starting point for our research either, because there is prior knowledge which is considered sufficiently large to develop a priori concepts. Alternatively, and supported by Edmondson and McManus' view on methodological fit, the case research methodology allows for a focused topic of conversation which is determined in advance and for the collection of reactions and interpretations in a relatively open form. The case method also is open for the introduction of concepts or categories which have been developed previously either through a literature review or via an empirical or conceptual study and is compatible with a focused interview of limited duration. This methodology also allows for the building of theory from which to develop hypotheses that can be tested in a follow-up research project and allows for the exploration of the phenomenon in a phenomenon-context relationship. Finally, the case study research approach is compatible with an exploratory research project. However, because CEOs were not inclined to make available confidential

Method	***Use***	***Decision***	***Arguments***	***Reference in this thesis***
Survey based research	Used in surveys in an attempt to link CEO demographics to innovation output	**Not selected**	Quantitative based approaches have not led to a better insight into the role of the CEO in innovation and does not elucidate the actual role of the CEO	Section 2.4
Grounded theory	Not used in CEO-innovation research	**Not selected**	The research does not – cannot – start 'ground up', unless a deliberate neglect of all previous research data and conclusions would be assumed. It can hardly be justified to neglect previous research data.	Section 3.3.1.
Case research	Not (yet) used in CEO-innovation research	**Not selected**	At first sight an acceptable approach but seen the reluctance of the CEOs to open up their confidential data (agendas and meeting minutes) this approach was not selected.	Section 3.3.3.
Exploratory descriptive research using research interviews	Not (yet) used in CEO-innovation research	**Selected**	Seen the availability of the CEOs and their willingness to enter into a interview conversation, an interview based approach was selected as part of exploratory descriptive research (Kvale, 2009)	Section 3.3.3. and Section 3.3.4.

Table 3-2 Ranges of possible approaches for the research and reasons for the choices

documents such as agendas and/or meeting minutes for reasons of confidentiality, the case study approach – in which each case would be explored and studied using all available information, processes, routines and personal data, was not feasible either. It was therefore decided to conduct this research using research interviews only as a means to explore and describe the roles of CEOs. In other words, the proposed research is of an exploratory descriptive nature and will make use of research interviews exclusively. The arguments for the selected methods are summarized in the table below.

3.4 Theoretical perspectives and a priori concepts

Exploration (in the social sciences) is 'positivistic, in part, because it is nomothetic, its principle goal being production of valid generalizations about a type of group, process, activity or situation' (Stebbins, 2001; p11). It was already argued by Stebbins (2001) that 'exploratory researchers are frequently enjoined to enter their area of study purged of all conceptualizations acquired in their past that might slant the present collection and interpretation of data'. According to Partington (2003):

> 'Apart from the obvious impossibility of … a theory-neutral state, management researchers attempting to operate from a 'clean slate' would be facing the impossible task of operationalizing an infinitely large number of potential variables. If you are building a theory it is important to start out with an explicit framework on which that theory can be developed. The framework should suit both your purpose and your research questions'

Partington (2003) argues that 'Theoretical frameworks in management research come in many different forms. They can range from elaborate multivariate conceptual-lizations and models to simple relationships between a few basic concepts' and '...frameworks which make explicit the researcher's ontological and epistemological assumptions provide the best foundation on which to construct and defend a theoretical argument'. Stebbins (2001) adds that 'basic concepts do abound that can help guide and expand exploration, while posing no significant threat of contamination to the collection and interpretation of data'.

In view of this research, Partington's statement that '.much management research is conducted in the positivist tradition, which holds that through observing regularities researchers can make generalizations, within defined limits, of relationships between variables' also applies to this research (Partington, 2003). However, as argued by the same author, these generalizations cannot be considered as predictive certainties as 'in the social world, observed regularities can do no more than express tendencies caused by underlying generative mechanisms which may or may not be brought into play in a given situation'. This critical realist theory of reality allows speculation about possible and plausible underlying generative mechanisms (Bashkar, 1975). The concept of the 'underlying generative mechanism' is what generated the first data on the role of the CEO in innovation, in an attempt to show that the causal factors for innovation were to be found in age, tenure, education, experience of the CEO etc.. Seen from this angle, the upper-echelons perspective (Hambrick and Mason, 1984) as discussed in the literature review, touches upon the critical realist framework proposed by Bashkar. Although the upper-echelons perspective was constructed to think about and research the role of the CEO, the proponents were criticized for not *directly* studying strategic leadership (Boal and Hooijberg, 2000; Priem, 1990; Damanpour and Schneider, 2006; DeTienne and Koberg, 2002). Nevertheless, this research has led to interesting conceptual thinking and allowed the weighing of CEO versus organizational and environmental factors on innovation. Other theoretical perspectives from leadership research have been explored and Appendix C offers an overview and discussion of theoretical frameworks that have not yet been used in CEO research.

Although it was not developed to understand the role of the CEO in innovation, Arendt's CEO model offers interesting perspectives to understand the role of the CEO in innovation (Arendt et al., 2005). According to Arendt et al., two models have been used to try to understand top-

level organizational decision making. The first model addresses the CEO as the unit of analysis and is presented in the literature as the 'CEO model'. It has resulted in research papers that study the impact of CEO-age, CEO -cognition, CEO-environmental scanning and CEO-pay among others, on strategic decision making. To the extent that the CEO model focuses on CEOs as lone decision makers 'the CEO model is an atomized, undersocialized conception of human action' that neglects 'the CEO's social context' (Granovetter, 1985) and 'CEOs would wield their power and make unilateral decisions... despite needing to address multiple, conflicting goals and evaluate a myriad options' (Cyert and March, 1963). Garten concludes that 'this would likely limit the extent to which CEOs would choose to be 'lone rangers' and make strategic decisions single-handedly' (Garten, 2001). The second model (TMT-model) used the top management team as the unit of analysis and depicts a decision making process that is shared by its members. The concept resulted in a broad range of scientific investigations addressing TMT-conflict, TMT-consensus, TMT-demographics and -composition, among others. According to Granovetter (Granovetter, 1985; p485), however, this model is an 'oversocialized conception' that 'does not recognize that TMTs tend to be hierarchical decision-making bodies in which involvement is not equal but, rather, is driven by the influence of advisory systems within and outside the firm'. In other words, equal participation by a firm's top managers is hindered by the presence of intrafirm coalitions, information asymmetries (Edmondson et al., 2003) or can 'presage adverse decisions when a firm's top managers *do* participate equally' (Arendt et al., 2005).

In view of the two models presented above and their criticism, Arendt et al. argue that 'accepting that the strategic decision making process for *some* decisions in *some* firms may conform to either the CEO model or the TMT model, many strategic decisions in many firms are neither made by a unilateral CEO nor by a TMT'. The authors therefore propose the 'CEO-Adviser model' which 'blends individual and group decision making... by recognizing that individuals involved in strategic decision making may come from anywhere in the firm's hierarchy and may not be consulted on all decisions' and which, they argue, is 'more authentic'. The CEO-Adviser model involves four characteristics: the CEO as the principal decision maker, the advisers to the CEO who can be internal or external to the firm, the selection of advisers by the CEO, and the dyadic communication between the CEO and advisers.

Applying the concept to this research. In view of the proposed CEO-Adviser model, the appropriateness of this model to the context of R&D and this research is discussed.

First, the model proposes – in line with established theory – that the CEO is the ultimate decision maker in the firm. This argument is independent of the firm's internal or external environment and therefore is applicable in the context of life science based R&D.

Second, the CEO-Adviser model's assertion is that strategic decision making is cha-racterized by ambiguity and complexity.

Third, because the 'type of information processed from a firm's environment is likely to be too great for any one person' this generates potential information overload.

Fourth, the model allows the study of the CEO in view of his/her interaction with social networks such as the R&D function (Florida, 2004; Alvesson, 2004)

These arguments are relevant in the context of a life science R&D firm where the complexities of science make it highly unlikely for a CEO to take decisions unilaterally and where the decision making process is complicated by the potential knowledge asymmetry between CEO and R&D (Styhre, 2009). Based upon the assumption that the role of the CEO in life science R&D may be driven by the interaction with the R&D function, Arendt et al.'s CEO-Adviser model offers a conceptual framework that is suitable and appropriate to conduct research in life-science R&D firms.

3.5 Research approach

3.5.1 Introduction

The literature review led to the decision to conduct research along 3 lines of conduct (see Chapter 2):

i. to study the CEO directly by means of a qualitative approach
ii. to use a combination of literature based themes of CEO attitude, -attention,-commitment, -involvement and –innovativeness in the single context of life science R&D firms
iii. to involve the R&D function to inquire how it perceives the role of the CEO seen its resistance to managerial practice and autonomy

In addition, it was decided to take a case study approach using interview based explorations (see Section 3.3). This means that the research requires the identification of CEOs and R&D executives who report to these CEOs both of whom are prepared to accept interview based inquisitive conversations. The 15 CEOs (plus 2 pilot CEOs) and the 33 R&D executives (plus 6 pilot R&D executives) who agreed to join the research project are listed in Appendix E and M respectively.

This section proceeds as follows. First, the context of the research is presented (3.5.2.) followed by a description of the research approach of the 2 research projects: CEO interviews (3.5.3.) and R&D interviews (3.5.4.). The section on CEO interviews is further divided in two sub-sections: Individual CEO interviews (3.5.3.1.) and CEO focus group research (3.5.3.2).

3.5.2 The context of research

The research takes place in small and medium-sized firms (according to EU, EMA (European Medicines Agency)-definition) known for their intensive life science R&D. The reason for the selection of these firms is as follows:

i. in SME life science R&D firms, the locus of innovation resides in senior and middle management and - if the CEO plays a role in innovation - that role should become clearly observable either through the arguments raised by the CEO and/or the arguments raised by R&D
ii. in SMEs, CEOs have a greater - more observable - impact on firm performance and innovation than in larger firms (Miller and Toulouse, 1986a)

In other words, small and medium-sized life science R&D firms were selected to increase the level of detection of observable roles of the CEO. In addition, to the group of SMEs, two big-

pharma cases were introduced (more than 1000 employees in R&D) to contrast the observations made with their CEOs and R&D executives with those of the CEOs and R&D executives of smaller firms. The following sections discuss the case study approach for the CEO and the R&D executives' interviews.

3.5.3 The research process

The process of the research presented in this thesis consists of 5 steps which are summarized in the table below. The table presents the 5 research steps, the description of each step, the objective, the decision point at the end of the research step, the outcome of the decision and the next step (Table 3-2 below; columns 1-6). Each step of the research process includes a decision point that is introduced in the table (4th column). Each decision point leads to a decision (5th column, outcome of the decision) that drives the next step (6th column). The first step of the research is the literature review. The second step addresses the individual interviews of the CEOs. The outcome of this research is then evaluated by means of a CEO focus group research (step 3) in which the observations of the CEO interviews are submitted to the group of CEOs to 'assess their familiarity with the individual observations' (Stebbins, 2001). The use of a focus group to ascertain a researcher's results against the group of interviewed individuals is considered an acceptable approach (Merton et al., 1990). In addition, the questions used during the interviews with the CEOs are then used to interrogate senior R&D managers who report to the CEOs (step 4). Doing so, the outcome of the research interviews of the CEOs are checked against the focus group observations and against the R&D interview observations. A schematic overview of the relationship between data collection, the instruments for data collection, data analysis and conclusion is presented in Figure 3-2 below.

3.5.4 CEO interviews

The CEO interviews were initiated with two pilot interviews (CEO1P and CEO2P) of which the procedure and the results are included in Appendix E. These pilot interviews were conducted to structure the final CEO interviews.

3.5.4.1 Individual CEO interviews

Research question

An essential element in a research project is 'that there should be one or more research questions to guide the inquiry and to provide focus' (Partington, 2003). The five concepts attitude, attention, commitment, involvement, innovativeness were previously used to conduct research on the role of the CEO in innovation in different industrial settings. The question whether they appear in different industrial contexts and therefore are 'generalizable' is a valid one. In other words, it is not clear whether concepts retrieved in – for example – governmental non-for-profit organizations can be found in life science R&D firms. Leseure (Leseure, 2000; cited by Laforet and Tann, 2006) observes that 'what works in one organization does not necessarily apply to another and managerial practices vary from one socio-economic culture to another'. For example, 'attitude' as a conceptual role of

Research step	*Description of the research step*	*Objective of the research step*	*Decision point*	*Outcome of the decision*	*Next step*
1	*Literature review (Chapter 2)*	*To obtain a comprehensive overview of scholarly research on the role of the CEO in innovation*	*Decision point 1 : Does the literature offer insight into the role of the CEO in innovation?*	*The research does not offer insight into the actual role of the CEO in innovation in life science R&D firms and is limited to quantitative surveys*	*The decision is taken to engage in qualitative descriptive research to explore the role of the CEO -> step 2*
2	*Individual CEO interviews (Chapter 4)*	*To obtain insight into the role of the CEO in innovation in life science R&D firms*	*Decision point 2 : The interview data represent a unidirectional view on the role of individual CEOs and it is therefore required to inquire whether these observations – when put forward to a group of CEOs can be – substantiated. In other words: do the data require additional scrutiny in order to increase our understanding of the role of the CEO and to validate the findings?*	*It is argued that the data of the individual CEO interviews require further substantiation by means of additional research within this group of CEOs*	*The research proceeds to the next step by submitting the research interview data to a group of CEOs as part of a focus group research -> step 3*
3	*CEO focus group research (Chapter 4)*	*To obtain confirmation of the findings of the actual role of the CEO in innovation from individual interviews by a group of CEOs*	*Decision point 3 : Do the combined focus group research data and the individual CEO interview data warrant further confirmation by inquiring with senior R&D managers about the role of the CEO?*	*It is argued that the research interview and the focus group data – although valuable in their own right – would profit from an additional research project in which these observations are checked against the observations made by senior R&D executives on the role of their CEOs*	*The research should proceed to the next step by conduc-ting research interview of senior R&D managers reporting to the CEOs -> step 4*
4	*Individual research interviews of senior R&D managers (Chapter 5)*	*To obtain confirmation of the findings of the role of the CEO in innovation from the individual CEO interviews and the focus group*	*Decision point 4 : Are the results of the individual interviews with the senior R&D managers such that a conclusion can be made about research steps 1, 2 and 3?*	*The combined data offer a comprehensive view of the role of the CEO as argued by CEOs and by R&D executives. The data have reached a level whereby a full analysis and comparison can be conducted*	*Analysis of all data and final conclusion -> step 5*
5	*Analysis and conclusion (Chapter 6 and 7)*				

Table 3-2 The research process and its decision points

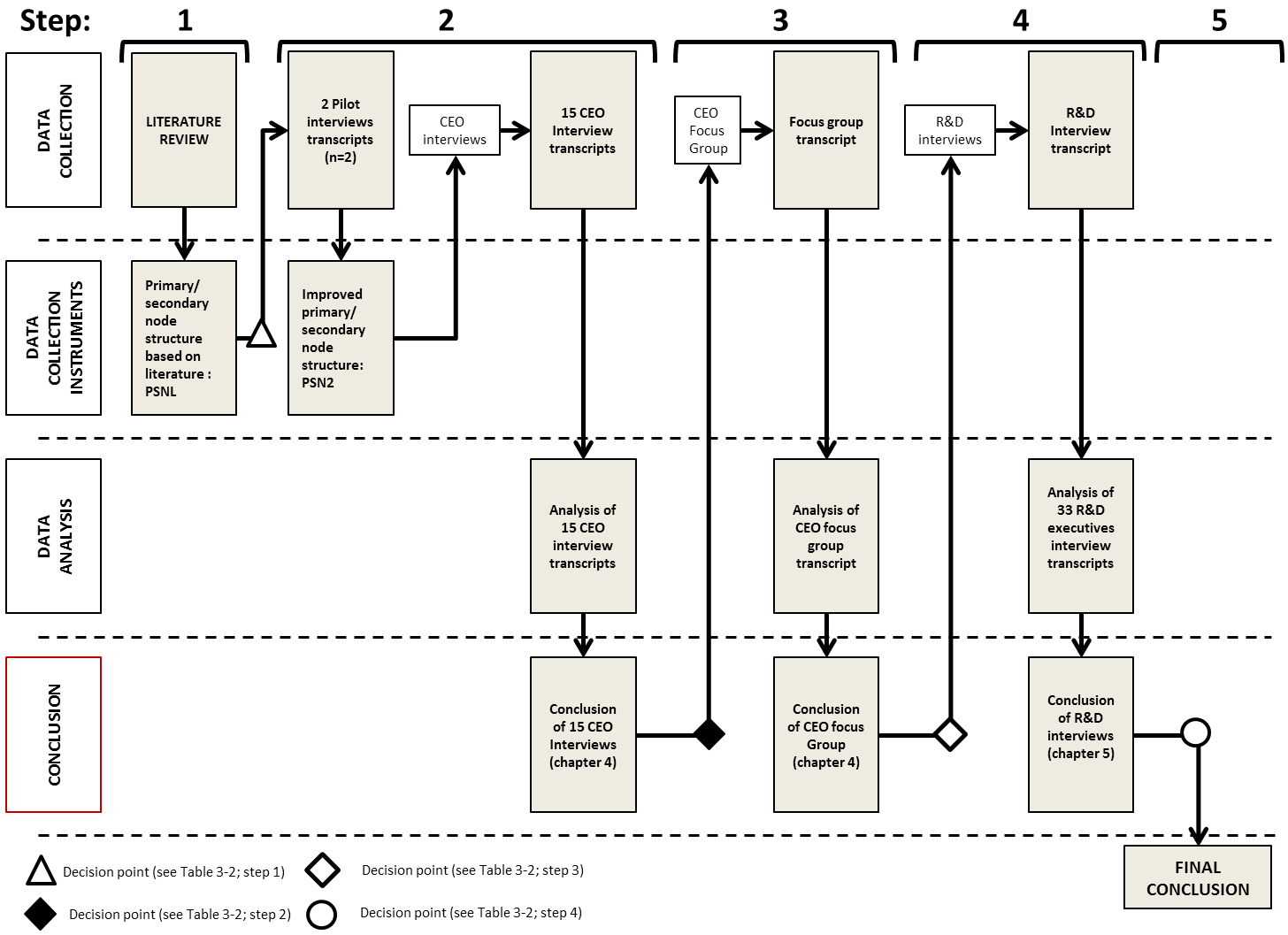

Figure 3-2 The research process

the CEO, was mentioned in Damanpour and Schneider's study in non-for profit organizations (Damanpour and Schneider, 2006) but was not mentioned in large industrial R&D or small IT firms. It can therefore not be assumed that the concept 'attitude', or any of the other concepts, can be used to describe the role of the CEO in a life science R&D firm or that no other concepts are required to describe that role.
Therefore, the research question is twofold

RQ 1 Do the literature concepts describing the role of a CEO in innovation reappear in the context of a life science R&D firm?

RQ2 Do new concepts describing the role of a CEO in innovation, other than those described in the literature, emerge in the context of a life science R&D firm?

From research questions to interview questions
As learned from the pilot interviews during which open ended interview questions were used but found unacceptable (see Appendix E), the interview approach for the final CEO interviews will need to consist of fixed, focused questions that 'pull' the CEO into a structured conversation. An important aspect of this research therefore involves the development of interview questions. Interview questions were developed that address the innovational environment in which the CEO operates, the goal of which is to generate reflections by the CEO that will offer the CEO's personal view on his role in innovation. A detailed description on how the interview questions were developed using the pentathlone framework of Goffin and Mitchell is presented in Appendix F. The final CEO interview questions are presented in Figure 3-3. The CEO reflections, collected through an interview and transcribed, will then be categorized according to a procedure presented in Appendix E.

The nature of the interview questions
It was argued in the beginning of this chapter that this research is of an exploratory nature and the use of structured interview questions may 'feel' contradictory: if research is exploratory then the nature of the questions should be less structured, on the contrary, they should be 'open' to allow exploration. It was found however that the use of open questions as tried during the first pilot interview was a risky approach because of the nature of the interviewees. The problem of interviewing elite is that it may have its 'talk tracks' ready for any interview and the interviewer requires considerable skill to get beyond. In order to obtain a better control on the interview process it was argued that a more structured approach was required in order to prevent the strong CEO personalities to direct the interview into 'war stories' that offer 'gloss' but not necessarily insight into their roles. In addition, structured interview questions do not necessarily limit the range of topics to be explored. The argument that only open interview questions would lead to a better insight is contradicted by the use of structured interviews that are broadly distributed over a wide range of innovation concepts using the innovation pentathlon of Goffin and Mitchell (2011) (see appendix F).

Cranfield UNIVERSITY
School of Management

Research project The role of the CEO in innovation
Researcher : J. Rosier

INTERVIEW QUESTIONS TO THE CHIEF EXECUTIVE OFFICER

Place of interview .....
CEO: .....
Time start .....
Time stop .....

Q1	What do you think are the attributes of the role of a CEO in a life science R&D firm?
Q2	What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm?
Q3	What is in your opinion the most important driving force for R&D innovation in the organization and why?
Q4	How do you create a climate of innovation and why?
Q5	Is an innovational climate important even in R&D firms which should be, by definition, innovative because of the nature of the work?
Q6	How much time and effort do you make available to obtain information from your R&D team in percentage?
Q7	How are new ideas developed in R&D?
Q8	How do you identify new ideas in your firm and exploit those ideas?
Q9	Are you actively looking yourself for new ideas in the organization?
Q10	What are your driving factors to invest in, make available resources and support R&D?
Q11	How do you as a CEO actually increase the output of R&D?
Q12	What are your incentives to stimulate innovation in R&D?
Q13	How do you live with and manage the risk associated with R&D?
Q14	How do you bridge the gap between the scientific/ biomedical knowledge in R&D and your (general management's) knowledge?
Q15	With whom and how frequently (times/w, m, y) do you actually discuss R&D, and why?
Q16	To what depth are you involved in the NPD discussions and why?
Q17	What is your role in advancing new product development?
Q18	How do you describe your role as CEO in R&D vs the role of your CSO?
Q19	Who takes R&D decisions and why?
Q20	Who decides on the final product design and why?
Q21	Who is the most important driver in new innovations in your firm?
Q22	Have you seen CEOs who were particularly effective in driving R&D, and why do you think they are?

Figure 3-3 CEO interview questionnaire

Data collection and analysis

As it was decided to conduct the research by means of structured interviews, there is a need to structure the approach and subsequent analysis of the interview transcripts. The analysis of interviews takes place by means of content analysis that consists in the detection of themes that emerge from the interviews (Krippendorff, 2013). A theme is then defined as an idea, conviction, view or proposition made by the interviewee (the CEO) that bears relevance to the topic of research, i.e. his/her role in innovation. The literature concepts of attitude, attention, commitment, involvement and innovativeness are used as 'major themes' that consist of 'subthemes' that contribute to the major theme. For example, a statement such as 'the CEO fosters a culture of innovation' is assigned as a subtheme to the major theme of 'attitude'. Each major theme and subtheme is codified to allow a structured analysis of the text. For example, if a CEO 'argues that he/she fosters a culture of innovation', this is identified as a subtheme that is assigned to the major theme of 'attitude' and is given a code 'ATI1'. Themes that cannot be assigned to any of the major themes or their subthemes are identified as 'other themes' and codified as 'CEO-OTHx' (or abbreviated as 'OTHx') indicating that the theme emerged from an interview with a CEO ('CEO-'), is different from the major and subthemes ('OTH') and is given a number 'x'. A detailed description of the procedure used for the transcription and content analysis, the identification of themes, subthemes and other themes, is presented in Appendix E. It is appropriate at this time to define terms that are used in this and the following research projects. They are summarized in Table 3-3.

Term	**Definition/description**
Role concept	Syn. role conceptualization: a role concept /conceptualization describes a characteristic that reflects an underlying role behavior. For example, attitude describes a positional stance that can be observed when discussing innovation with CEOs
A priori role concept	A role concept that is defined in the literature, for example: CEO attention or CEO attitude
A priori theme (or major theme)	A theme that emerges from the systematic content analysis of the interview transcript and can be identified as an a priori role concept
Sub theme	A theme that emerges from the systematic content analysis of the interview transcript and is supportive of an a priori theme
Other theme (or new theme)	A theme that emerges from the systematic content analysis of the interview transcript and cannot be assigned to an a priori theme

Table 3-3 Overview of terms used in the research

The general approach for the systematic analysis is as follows:

Step 1. A theme structure identified as a primary/secondary node structure (PSN structure) for use in NVivo analysis is developed based on the 2 CEO pilot interviews (see Appendix E). The 'primary' nodes in this PSN structure represent the major themes: attitude ATI, attention ATT, commitment COM, involvement INV, innovativeness INN while the secondary nodes represent subthemes such as ATI1, ATI2 etc. derived from

the literature. The pilot interviews also led to other themes and they are presented as 'CEO-OTH' or abbreviated as 'OTH' (primary node) and respective secondary nodes (OTH1, 2 etc.). This is presented in Table 3-4.

ATI Attitude
ATI1 CEO fosters a culture of innovation
ATI2 CEO fosters experimentation and accepts failures
ATI3 CEO fosters internal communication
ATI4 CEO fosters the exchange of diverse ideas
ATI5 CEO fosters external collaboration to increase internal innovation
ATI6 CEO fosters flexibility and adaptability
ATI7 CEO fosters learning in the organization
ATT Attention
ATT1 CEO sets the direction/goal and vision in which innovation to take place
ATT2 CEO sets the focus and boundaries in which innovation to take place
COM Commitment
COM1 CEO hires selects and develops innovative leadership
COM2 CEO creates incentives and rewards for the R&D function
COM3 CEO prioritizes resources
COM4 CEO makes available human and financial resources
COM5 CEO empowers R&D to execute on new ideas
COM6 CEO creates hierarchical flat organizational structures for innovation
COM7 CEO reduces development risk by hiring expert people and developing options
INV Involvement
INV1 CEO challenges R&D for efficiency
INV2 CEO challenges R&D technically
INV3 CEO acts as sounding board
INV4 CEO interacts with R&D to solve technical problems
INV5 CEO is involved in NPD
INV6 CEO holds frequent formalized meetings with R&D
INN Innovator
INN1 CEO drives new product development in person
INN2 CEO takes control of every detail of NDP
INN3 CEO wants to transform/disrupt the market
OTH Other roles or themes (from the pilot studies)
OTH1 CEO admits limited knowledge in specific R&D area
OTH2 CEO admits not driving innovation but rather the direction of innovation
OTH3 CEO interacts with R&D only in those matters he/she has personal knowledge in
OTH4 CEO should not focus on technology
OTH5 CEO stresses the importance of strong knowledge in the field of innovation
OTH6 CEO requires R&D data to be simplified for strategic decision and communicaton
OTH7 CEO wants R&D to step out of academic thinking
OTH8 CEO role model is knowledge based
OTH9 CEO aims to obtain respect from R&D
OTH10 CEO attempts to understand R&D expertise
OTH 11 CEO carries R&D through difficult times
OTH12 CEO considers it an advantage to be untrained in science
OTH13 CEO considers himself at a disadvantage as a non-scientist

OTH14 CEO informs R&D about the company's position
OTH15 CEO role model is business driven
OTH16 CEO wants to protect R&D from the mundane aspects of running a firm

Table 3-4 Primary/secondary node structure 'PSN2'

This primary/secondary node structure is identified as primary/secondary node structure 'PSN2' because it was developed after the *second* pilot interview (see Appendix E).

Step 2. the PSN2 instrument is then used to systematically analyze the CEO interview transcripts. As a result of this analysis, new themes were introduced in the primary/secondary node structure PSN2 and hence PSN2 developed in a more extended primary/secondary node structure as more and more interviews were analyzed. This led eventually to 'PSNn', or the nth primary/secondary node structure obtained after the last CEO interview. This PSNn instrument was then used again to re-analyze all the interviews of the CEOs. This approach is represented in extensive detail in Appendix E.

Step3. The themes are then collected and their frequency counted in order to obtain insight in the weight by which themes and subthemes emerged from the interviews (Krippendorff, 2013).

3.5.4.2 CEO focus group research

Introduction

The objective of this research is to inquire how CEOs, when brought together, respond to the findings of the interviews of their colleague-CEOs. Doing so, this focus group research acts as validation instrument to evaluate whether the observations made by the interviewer sound familiar with the CEOs and whether any of the comments raised, generate new ideas or themes that would give additional clarification of their roles in innovation. It was therefore decided to establish a focus group whereby the interviewed CEOs were invited to attend and to participate in a discussion of the findings of the CEO interviews.

According to Morgan (1997), 'focus groups are basically group interviews, although not in the sense of an alternation between a researcher's questions and the research participants' responses. Instead, the reliance is on interaction within the group, based on topics that are supplied by the researcher who typically takes the role of a moderator'. Although focus group research can be used as a 'self-contained social inquiry method in which they serve as the principal source of data, in this case, the method is used as a supplementary source of data in studies that rely on some other primary method such as individual interviews' (Morgan, 1997). In other words, the focus group research method is used to add to the data gathered through the individual CEO interviews and the same CEOs who were interviewed were invited to take part. Four broad criteria should be met for the conduct of effective focus group interview:

- the range of topics: the range of the topics covered in the focus group research

- the specificity of the data: the provision of data for a focus group research
- the depth of the interaction: the fostering of interaction that explores the participant's feelings in some depth
- the personal context: the taking into account of the context that participants use in generating their responses to the topic

These four requirements are discussed below in view of our research project.

The range of topics refers to topics which may have been identified via other qualitative techniques and which reappear during the focus group discussions. Alternatively, new topics or themes emerge that the researchers had not anticipated (Merton et al., 1990). However, according to Merton, 'researchers sometimes inad-vertently narrow the discussion by implicitly assuming which themes are important' (Merton et al., 1990). It should be avoided to moderate the discussion such that the observations are either up- or downgraded. In this research, the range of topics that was introduced in the focus group discussion was limited by and derived from the CEO interviews.

Merton et al. emphasize 'specificity to direct the focus group discussions toward concrete and detailed accounts of the participants' experiences' because 'it can be all too easy for participants to drift into generalities, but an emphasis on hearing about the participants experiences can help to counteract this tendency'. This is particularly important, as it was observed during the pilot interviews that they tended to drift into the story telling of 'war stories' (see Appendix E), an observation that forced the decision to develop a structured interview rather than an open interview approach (which was used for the pilot interviews, see Appendix E). In the case of the focus group meeting, their interest into the topic became clear during the interviews and the interaction afterwards, and guaranteed focus without the tendency of falling back into 'war story' telling.

A third topic of interest is the topic of 'depth of interaction' which is linked to the participant's involvement with the material he/she discusses. According to Merton et al. the 'goal is to avoid a discussion of vague generalities'. This is less important, according to Merton et al. (1990), with 'participants who are highly involved with a topic because they already have a motivation to share opinions and experiences'. This is the case with our focus group research as the CEOs who volunteered to join the focus group showed a keen interest in discussing the role of the CEO in innovation.

The final criterion offered by Merton et al. is the attention to the personal context from which the individual comments arise and 'the point of doing a focus group research is to bring a number of different perspectives into contact' (Merton et al. 1990). In our case, not only are the 4 CEOs different personalities with different educational backgrounds and experiences, they also run companies that are different in view of the number of R&D scientists that they employ and the nature of life science R&D that they conduct.

Research question

The main objective of a focus group research– in contrast with an individual interview approach – is to observe the interaction among the focus group participants (Morgan, 1997). To observe the interaction is to specifically look for assertion, comments, and

quotes that are the direct result of that interaction in order to either ascertain previous themes or to identify new themes. The objective of this focus group research with the CEOs is to answer the following research question (which is the interview question):

RQ Are the conclusions of the CEO and the R&D interviews, either strengthened, weakened or even extended with new themes when put forward to this group of CEOs to which the research conclusions are presented?

3.5.4.3 Research procedure

The selection of the CEOs for the focus group and the approach used, is presented in Appendix J.

3.5.5 R&D interviews

The objective of the interviews of the R&D executives is to gain insight in the role of the CEO as perceived by the R&D function. The interviews started with 6 R&D pilot interviews, of which the procedures and results are included in Appendix L. The R&D executives who joined the interviews are listed in Appendix M.

3.5.5.1 Research question

This research addresses the question whether the CEO role behaviors, as stated by the CEOs, are also perceived as such by R&D executives and whether they use the same – or other - CEO role descriptions. Therefore, the research questions are:

RQ 1 Are the role concepts used by CEOs in innovation in life science R&D also perceived by the R&D function?

RQ2 Does the R&D function use concepts to describe the role of a CEO in innovation, other than those used by the CEOs?

These research questions are transformed into interview questions. The approach used for this transformation is presented in Appendix J. The resulting R&D questionnaire is presented in Figure 3-4 below.

3.5.5.2 Research procedure

The analysis of the R&D interviews takes place by means of a systematic content analysis of the interview transcripts and consists in the detection of themes that emerge from the interviews. A theme is defined as an idea, conviction, view or proposition made by the interviewee (the R&D executive) that bears relevance to the topic of research, i.e. his/her perception of the CEO's role in innovation. The literature based a priori themes of attitude, attention, commitment, involvement and innovativeness are used as 'major themes' that consist of 'subthemes' that contribute

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Research project The role of the CEO in innovation
Researcher : J. Rosier – Supervisor Prof. K. Goffin

INTERVIEW QUESTIONS TO THE R&D EXECUTIVE

Place of interview .....
CEO: .....
Time start .....
Time stop .....

Q1	What do you think are the attributes of the role of a CEO in a life science R&D firm?
Q2	What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm?
Q3	What is in your opinion the most important driving force for R&D innovation in the organization and why?
Q4	How does he/she create a climate of innovation and why?
Q5	Is an innovational climate important even in R&D firms which should be, by definition, innovative because of the nature of the work?
Q6	How much time and effort does he/she make available to obtain information from your R&D team in percentage?
Q7	How are new ideas developed in R&D?
Q8	How does he/she identify new ideas in your firm and exploit those ideas?
Q9	Is he/she actively looking yourself for new ideas in the organization?
Q10	What are his/her driving factors to invest in, make available resources and support R&D?
Q11	How does he/she as a CEO actually increase the output of R&D?
Q12	What are his/her incentives to stimulate innovation in R&D?
Q13	How do you think does he/she live with and manage the risk associated with R&D?
Q14	How does he/she bridges the gap between the scientific/ biomedical knowledge in R&D and your (general management's) knowledge?
Q15	With whom and how frequently (times/w, m, y) does he/she actually discuss R&D, and why?
Q17	To what depth is he/she involved in the NPD discussions and why?
Q18	What is his/her role in advancing new product development?
Q19	How does he/she describe your role as CEO in R&D vs the role of your CSO?
Q19	Who takes R&D decisions and why?
Q20	Who decides on the final product design and why?
Q21	Who is the most important driver in new innovations in your firm?
Q22	Have you seen CEOs who were particularly effective in driving R&D, and why do you think they are?

Figure 3-4 R&D interview questionnaire

to the major theme. For example, a statement such as 'our CEO fosters a culture of innovation' is assigned as a subtheme to the major theme of 'CEO attitude'. Each major theme and subthemes are codified to allow a structured analysis of the R&D executives' interview transcript. For example, if a R&D executive argues that 'my CEO fosters a culture of innovation', this is defined as a subtheme that is assigned to the major theme of 'attitude' and is given a code (ATI1). Themes that emerge from the R&D executive interviews and that cannot be assigned to any of the literature based a priori themes are either assigned to a theme that was developed earlier by the CEOs during their interviews and codified using codes 'CEO-OTHx' (see above) or to a new theme, exclusively used by R&D executives and codified as 'RD-OTHx', indicating that the theme emerged from an interview with a R&D executive ('RD'), is different from the other themes (either literature based or developed by a CEO) ('OTH') and is given a number 'x'. A detailed description of the procedure used for the interviews of the R&D executives is presented in Appendix L.

3.6 Analysis of the data

3.6.1 Quantitative analysis of qualitative data

As will be observed in the following chapters, the interview data will not only undergo a qualitative analysis using the a priori based concepts, but they will also be subjected to a quantitative analysis in order to obtain an understanding of the intensity by which some concepts re-emerge during the interviews. According to Krippendorf, themes can be collected and their frequency counted in order to obtain insight in the weight by which themes and subthemes emerge (Krippendorff, 2013). When analyzing transcripts from interviews, one is tempted – especially when one has a natural science background - to quantify the data that emerges from qualitative sources. The analysis of the content of the interview transcripts therefore draws from Krippendorff's treatise on content analysis (Krippendorff, 2013) in which the author argues that the evaluation of qualitative data using quantitative analysis is feasible and acceptable but only with utmost caution because

> 'it is most important to keep their Janus-faced character in mind'

Therefore, our analysis draws only tangentially from a quantitative analysis. Ward (2007) comments upon on the quantification of qualitative data as follows:

> 'Qualitative researchers may criticize quantification of qualitative data, suggesting that such an inversion sublimates the very qualities that make qualitative data distinctive: narrative layering and textual meaning. … (However) with the quantifying of qualitative data, framing it in a scientific construct, one is capable … of allowing numbers to "speak" in order to enhance our understanding of data'

Therefore, the data that will emerge from the interviews will also undergo a simple quantitative analysis (by means of measuring the frequency of appearance of themes).

3.6.2 Data

The analysis of the interviews for the CEO interviews, the CEO focus group and the R&D interviews is presented in extensive detail (procedures, questionnaire, interview observations, operational data, content analysis etc.) in the appendices summarized below.

Research data:	CEO interviews		Individual R&D interviews
	Individual CEO interviews	CEO focus group	
Introduction and pilot studies	App. E	App. J	App. L
From research questions to interview questions	App. F	App. J	App. L
Interview transcript analysis& results	App. H	App. K	App. O
List of CEOs and R&D executives	App. E	App. J	App. M
Interview observations	App. I	App. K	App. P
Operational data	App. G	App. J	App. N

Table 3-5 Overview of the appendices in which detailed research data can be found

Figure 3-5 offers a schematic overview of how the data find their way into the final conclusion in the last chapter.

3.7 Alignment of purpose, method and outcome

The alignment of purpose, method and outcome is presented in the table below (Table 3.6). It presents the purpose of the proposed research, the methods used to achieve the objective and the outcome of each. The main purpose of the research is to obtain insight into the actual role of the CEO. In order to do achieve this purpose, it was decided to explore this role by directly approaching CEOs and R&D executives by means of research interviews, an approach that hitherto was not used in research that addresses the role of the CEO in innovation. It stands in contrast with previous investigations where the role of the CEO was explored using surveys and by linking CEO demographics to innovation output. Therefore, it is argued here that the purpose of the study (understanding the CEO's role), the methods (structured research interviews) and the outcomes (a better understanding) are aligned.

As a result, the outcome of each of these methods (CEO interviews, CEO focus group and R&D interviews) is aligned with the purpose of the research, i.e. the description of the role of the CEO in in innovation in a life science firm. We will come back to this table in Chapter 7 Discussion and conclusion.

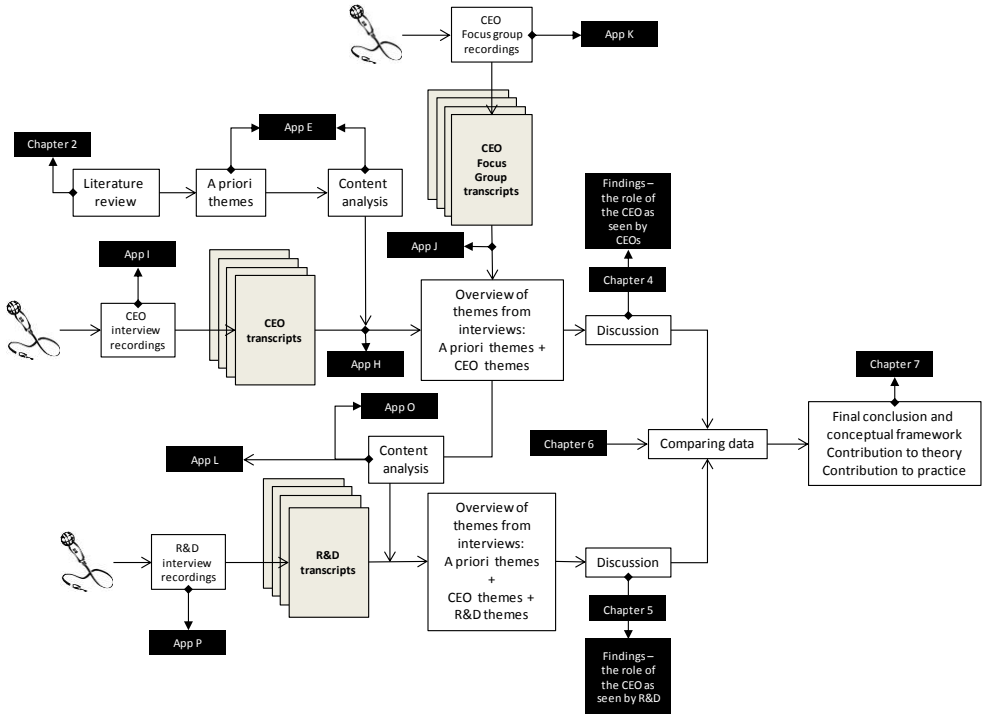

Figure 3-5 Overview of data analysis and flow

Purpose	*Method*	*Objective*	*Outcome*
To better understand the role of the CEO in innovation in life science R&D firms	*Research interviews of 15 CEOs*	*To obtain a description of the role of the CEO in innovation as seen by CEOs*	*A description of the role that CEOs play in innovation in a R&D life science setting as viewed by the CEOs*
	CEO focus group of 4 CEOs to which the observations of the individual CEO interviews are presented	*To inquire whether CEOs agree among themselves about the described role by each of the CEOs*	*To find support by the focus group CEOs for the statements made individually by the their colleague CEOs thereby supporting the validity of the research observations during the individual CEO interviews*
	Research interviews of 33 R&D managers reporting to the 15 CEOs	*To inquire whether the role description offered by the CEO is perceived as such by R&D*	*To ascertain the validity of the research observations during the individual CEO interviews by using the R&D manager's point of view on the role of the CEO thereby avoiding potential bias from the part of the interviewer*

Table 3-6 Alignment of purpose, method and outcome

3.8 Summary

The research design consists of exploratory descriptive research into the role of CEOs in innovation in life science R&D firms using structured interviews. It is divided in two parts.

The first part (Chapter 4) consists of structured interviews of 15 CEOs, the majority of which run small and medium sized life science R&D firms that have an R&D function headed by a director/VP R&D or a CSO and innovate by internal R&D. Two CEOs run a big-pharma company. The interviews are continued during a CEO focus group research of 4 CEOs. The concepts retrieved from the literature, and used as a priori themes for content analysis, are: CEO-attitude, -attention, -commitment, -involvement and -innovativeness. New themes that emerge during the interviews will be assigned to an a priori theme codified as ATI (attitude), ATT (attention), COM (commitment), INV (involvement) and INN (innovativeness) or to a new theme that cannot be assigned to the literature based a priori concepts. The objective of the first part of our research is to allow the 15 CEOs to *describe* their role in innovation such that it becomes clear of what they actually do when they lead innovation in their firms.

The second part (Chapter 5) consists of structured interviews of 33 R&D executives who report to the interviewed CEOs in an attempt to explore whether the description that CEOs use to refer to their role in innovation and the themes raised, are perceived as such by R&D executives or whether new themes emerge.

4 Findings - the role of the CEO as seen by CEOs

4.1 Introduction

This chapter is the first part of the research and constitutes the view of CEOs as they reflect on their role in innovation. It presents the findings of the structured interview of 15 CEOs. It is divided in five parts. First the findings of the individual CEO interviews are presented in Section 4.2. It is divided in an example interview (4.2.1.) and the findings of the final CEO interviews (4.2.2.). It is then followed by the findings of the CEO focus group research (4.3). The data are discussed in Section 4.4. and summarized in Section 4.5. The objective of the research reported in this chapter was to explore the self-perception of the CEOs as to their role in innovation in life science R&D firms and to inquire whether they use literature based a priori themes such as attitude, attention, commitment, involvement or innovativeness to describe their roles and/or use other themes.

4.2 Individual CEO interviews

4.2.1 Example interview

This section presents an example of a CEO interview in an attempt to offer the reader a flavor of the richness of the interviews. It is not a complete transcript but a four page extract of some crucial moments during the interview with CEO2, a serial CEO of some well known and reputed life science R&D firms. The sample starts when the discussion is on innovation in life science R&D firm and the unusual characters scientists are.

> *INTERVIEWER*
> *Dr. (name of CEO), thank you for this interview, let us start with the first question : what do you think are the attributes of the role of a CEO in innovation?*
>
> *CEO2*
> *I think what you try to do is create an environment where it can happen, I think you have to do that - when you've got an organization like ours, you know … we've gone from an academic start up to a platform company, through to products in the clinic and going through all those phases you become more and more formalized as you go through, you raise more money, you become public, you have more deadlines that are important and meet more demanding stakeholders and within that framework you have a lot of delivery tasks to achieve whether it be financial goals, R&D goals whatever they may be and at the same time what you're trying to do is to keep the structure out here where innovation is more free to occur because I think that's important. By that…I just mean…allowing people, allowing some space for pure research ideas to take place outside the very tough constraints of the day to day deliver this by tomorrow…*

.... if we're talking about the research innovators, they are more unusual characters very often, they're not normally straight forward in the way they behave or they interact and its really keeping a cage where you protect them from the outside organization and also protect the organization from them to some degree .... they're moving in a different way than the rest of the organization, you don't expect them to turn up for the corporate meetings, you don't expect them to know what our cash balance is, you don't expect them to know what the next milestone is, that's the way they think about the world at all and it is that dynamic between that and the rest of the organization... they are very powerful individuals generally, with a lot more freedom to explore ideas, to think about anything basically that they want to think about ... I'm not exactly sure to say what they're doing...

INTERVIEWER
What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm …?

CEO2
Grey hair is always helpful! I think that particularly in life science companies though I think most of our employees are scientists now … I'm a PhD in science but I stopped science very soon after I did a PhD so I would never call myself a scientist, I think one of my most important functions I think is to make sure that the scientists in the company believe I understand at any level what they're doing … one of the things a CEO has to be able to do is that everybody should be very, very afraid of trying to tell him anything that's not true about the science, not that I can compete with these people in the science but I can tell when I'm being told rubbish, I can tell when there isn't support to the idea and I think that allows me to challenge not just the finance guy, not just the commercial guy but also any science that is presented to me, or all clinical data that's presented to me, not above that level but I think I'm stronger from the high level side of its principles that if the sound data isn't there … and most importantly I think the ability to be confident to say I don't understand what you just told me, tell me again until I do and we're not leaving the room until you do, if you feel weak about yourself in the science, it's very hard for you to do I think, I don't feel weak and I just sometimes take three times to understand it, but if I don't get it by the third time it's their fault, there's something wrong about their logic, about the thing ...

I think the other key thing is to be able to reduce this complexity to simple ideas, one of my current themes in the organization is that the technical people will come and present me with a new idea … it will be

35 power point slides and by number 3 I'm already twitching and I know it's very simple…but the idea that you can't reduce half a pager to one or two slides, an important idea or concept (I know you can't produce all the data) … distill out the important, the core, when you've got so much heavy technical stuff and potentially heavy commercial stuff and clinical stuff all floating in there, what's the thing at the heart of that, what's the business proposition, what's the thing you take to an investor, what's the thing you say to a new employee as you're trying to track him into the company or whatever, what's the distillation of all this complexity because we could take a year to tell you what we do or we could take five minutes to tell you what we do and I think its my job to be able to do the five minute elevator pitch and I don't mean that superficially, I think its get the best out of what we do, so I think that communicating as a leadership thing is very important...

INTERVIEWER
How do you create a climate of innovation?

CEO2
I think it goes from the very top, make sure that its clear that you want that to happen in the organization, you have to draw some sort of framework where you say this is a playground…and for instance in that sort of group we also tend to keep the managerial structures very flat so people don't have to do lots of management of people, they don't have to worry about appraisals and all this sort of stuff, they do less of that than any other part of the organization because it doesn't work very well for many where they hate all that stuff, they don't do it well and if you can keep it as flat as possible, that seems to work very well…

INTERVIEWER
Are you actively looking yourself for new ideas as a CEO?...

CEO2
I think more as a facilitator so I think I'm approached quite a lot, so if I'm at a conference, just through email, people come to me with what do you think about this and I would be an initial screen you know...

INTERVIEWER
How do you as a CEO actually increase output of R&D ..?

CEO2
I think in general, output is an important role with the CEO, in all honesty I think we struggle to measure it, I think we're trying again to measure it, what the output is and bringing in real benchmarks but I think we struggle with that, I think quite honestly what you do as CEO is you

create more and more pressure until a time that you think the pressure is enough and it becomes negative, if you can't measure …

INTERVIEWER
What are your incentives to stimulate innovation?

CEO2
Nothing formal I think that's – so people don't get money, they get recognition.

INTERVIEWER
And how is that shown that recognition?

CEO2
I think what we're currently doing is identifying or have identified what we call the high performers which are generally the innovators around the organization, a lot of them are innovative … with them we're doing on a case by case basis interviews where we identify what makes them tick, what do they need, some of them want a hat, some of them want some stripes, some of them want 50 Euros a month, some of them want a car, some of them don't want anything except me to pat them on the back every day, each of us are turned on by different things like that and we're trying to get at the heart of that innovating group and see what they want rather than try and present a 500 Euro bonus for someone who comes up with a bright idea, we think that's all a bit of a plain tool, we're trying to custom design on a person by person basis.

INTERVIEWER
To what depth are you involved in those discussions....?

CEO2
I think with a clinical trial I'd be engaged at the beginning when we design the format for the trial, when we buy into what we're trying to do and what we're trying to achieve what the size of the trial is and what the consequence of the trial is, understanding and mapping that out and once a trial starts I'm generally only involved when things go wrong otherwise I'm getting told once a week, once every two weeks - its fine don't worry, we're doing exactly what we said we'd do...

INTERVIEWER
Do you sometimes go down to the labs and to talk to the scientists?

CEO2

Quite rarely mainly because two reasons 1) because we're working to more and more regulated environments and me just walking into a lab, it disturbs the flow, it also its what I've heard … our CSO did do in the past and I wouldn't do because its more expected that the CSO goes in and says what are you doing with that gel and how does that work and what's going on so immediately it makes people a bit more nervous so I tend to wait more in the project teams when they're prepared and they seem more comfortable and they know what they're going to try and present to me.

4.2.2 Final CEO interviews

The operational interview data are presented in Appendix G. The findings are presented below and divided in three sections. The first section (4.2.2.1.) presents the raw data obtained from the content analysis. The data are presented in five steps. First, the distribution of the major themes (attention, attitude, commitment, involvement and innovativeness and the 'CEO other roles'-theme) is presented (see below under 4.2.2.1. Content analysis, *Distribution of major themes*). Second, a number of new subthemes that emerged from the interviews will be identified (see below: *New subthemes*). Third, the relative distribution of subthemes is reported (see below: *Distribution of subthemes*). Fourth, further subtheme categorization is conducted and a number of themes are brought together under single themes (see below: *Further theme categorization*). Fifth, the data are analyzed in order to allow the identification of subthemes which are worth exploring further (see below: *Subtheme analysis*). The second section (4.2.2.2.) presents interview observations.

4.2.2.1 Content analysis

The findings of the content analysis are tabulated in Table 4-1 below. It presents the different themes that emerged from the interviews: attitude, attention, commitment, involvement, innovativeness and other themes each with their subthemes. For example, the major theme attitude, 'ATI' collects a number of subthemes 'ATI1' to 'ATI9'. New themes have also emerged under the major theme 'CEO-OTH' as 'CEO-OTH1' to 'CEO-OTH53'. The table also presents:

Nt: the number of times the theme or subtheme appears in all interviews
Ni: the number of interviews in which the theme emerges
Ri: the ratio of the number of interviews in which the theme appears to the total number of interviews. It represents the fraction of interviews in which the theme emerged

Distribution of major themes

For each transcript that was analyzed, the frequency of appearance of an a priori theme (attitude, attention, commitment, involvement, innovator) and the themes under 'CEO other roles' are collected and presented in Table 4-1. For example, in the

interview with CEO1, he/she referred to an attitude related theme 12 times (i.e. ATI1, 1 time; ATI2, 1 time; ATI3, 3 times; ATI4, 1 time; ATI5, 3 times; ATI6, never; ATI7, 2 times; ATI8, 1 time; ATI9, never; or in total: 1+1+3+1+3+0+2+1+0 = 12). CEO4 uses 13 'CEO-other' themes to describe his/her role (i.e. CEO-OTH6, 2 times; CEO-OTH10, 1 time; CEO-OTH12, 1 time; CEO-OTH19, 2 times; CEO-OTH20, 1 time; CEO-OTH21, 1 time; CEO-OTH22, 2 times; CEO-OTH23, 1 time; CEO-OTH24, 1 time; CEO-OTH25, 1 time or in total: 2+1+1+2+1+1+2+1+1+1 = 13 times). The a priori themes of attitude, attention, commitment and involvement and their related themes are mentioned respectively 67, 48, 58 and 47 times in total (see shaded areas in Table 4-1). The theme of CEO innovativeness is only mentioned once during the interviews (by CEO9). The data shows that:

- all CEOs address the concepts of attitude, attention, commitment and involvement in varying degrees,
- only one CEO (CEO9) referred to the concept of innovator. It was the CEO academician/founder of the firm. Overall, no CEO referred to his/her role as the driver of new product development, takes control of every detail of the new product development process and/or develops his/her idea in order to transform/disrupt the market with new products
- CEOs use a myriad of other themes to describe their role in innovation (CEO-other: CEO-OTH1 to CEO-OTH53). This indicates that a priori concepts only represent a fraction of the role descriptions that are used by CEOs. Especially CEO14 was creative in raising themes on his/her role in innovation which were not defined earlier.

New Subthemes

In the a priori theme of ATI 'attitude', 2 new subthemes appeared (the other subthemes ATI1 to ATI7 were part of the primary/secondary node structure used to analyze the interview transcripts): (ATI8): 'CEO states processes may stifle innovation' and (ATI9): 'CEO has an inquisitive nature: asking, listening, probing'. They refer respectively to one of the CEO's argument that a culture of innovation is difficult to attain if business processes prevent the use of experimentation and the challenging of established procedures. ATI9 refers to the attitude of CEO8 who argued that an important task of a life science R&D-CEO is to 'ask questions' that are 'inquisitive, probing' in order to better understand the details, the underlying mechanisms or processes of a R&D problem. The CEO underlined that this process of 'inquiring and probing' is different from the attitude of challenging, but rather an approach that led him/her to uncover hidden ideas and propositions that cannot be unveiled by a challenging process that is destined to search for the limits of an undertaking rather than the depth of it. Another new subtheme was assigned to the theme of commitment and referred to the CEO's role to secure sufficient financial resources and to manage an ideal cash flow for the firm (COM8). Under the theme of involvement, four new subthemes appeared. Subtheme INV7: 'CEO is involved at the start of an R&D project and then delegates it' referred to the statement made by CEOs who argued that involvement is not linked to discussions *during* the R&D project but is

Number of times a theme (left column) emerges in an interview with a CEO: CEO1 - CEO15 ↓

Cross-case→ / Within case ↓	CEO1	CEO2	CEO3	CEO4	CEO5	CEO6	CEO7	CEO8	CEO9	CEO10	CEO11	CEO12	CEO13	CEO14	CEO15			
Themes and subthemes																**Nt**	**Ni**	**Ri**
ATI ATTITUDE																**67**	**14**	**0,9**
ATI1 CEO fosters a culture of innovation	1	1	1		1	1		1		1		2	1		3	**13**	**10**	**0.7**
ATI2 CEO fosters experimentation and accepts failures	1	1	1		1		1						1			**6**	**6**	**0.4**
ATI3 CEO fosters internal communication	3	3	1	2			1	1								**11**	**6**	**0.4**
ATI4 CEO fosters the exchange of diverse ideas	1	2	2		1		3	1								**10**	**6**	**0.4**
ATI5 CEO fosters external collaboration to increase internal innovation	3	1	3		1	1	1	2	1		1	1	1			**16**	**11**	**0.7**
ATI6 CEO fosters flexibility and adaptability				1				1								**2**	**2**	**0.1**
ATI7 CEO fosters learning in the organization	2			2				1								**5**	**3**	**0.2**
ATI8 CEO states that processes may stifle innovation	1	1			1			0								**3**	**3**	**0.2**
ATI9 CEO has an inquisitive nature: asking, listening, probing								1								**1**	**1**	**0.1**
ATT ATTENTION																**48**	**14**	**0,9**
ATT1 CEO sets the direction/goal and vision in which innovation to take place	3		2	2	1	1	3	2	1	3	2		3		3	**26**	**12**	**0.8**
ATT2 CEO sets the focus and boundaries in which innovation to take place	3	1	2		1	1	2	1	2	1	1	3	2		2	**22**	**13**	**0.9**
COM COMMITMENT																**58**	**14**	**0,9**
COM1 CEO hires selects and develops innovative leadership	2		2		1		2	1			1				1	**10**	**7**	**0.5**
COM2 CEO creates incentives and rewards for the R&D function	1	1	1		1	2	1	1								**8**	**7**	**0.5**
COM3 CEO prioritizes resources	2	1	1												4	**8**	**4**	**0.3**
COM4 CEO makes available human and financial resources		1	1		2	1			1			2			1	**9**	**7**	**0.5**
COM5 CEO empowers R&D to execute on new ideas	1		1		3	1										**6**	**4**	**0.3**
COM6 CEO creates hierarchical flat organizational structures for innovation	1	2	1	2	2	1	1	1	1	1				1	1	**15**	**12**	**0.8**
COM7 CEO reduces development risk by hiring expert people and developing options							1									**1**	**1**	**0.1**
COM8 CEO manages ideal cash flow for LFRD firms				1												**1**	**1**	**0.1**

INV INVOLVEMENT																**47**		
INV1 CEO challenges R&D for efficiency		1		1	1		1				1	2			1	**8**	**7**	**0.5**
INV2 CEO challenges R&D technically		1								1		2			2	**6**	**4**	**0.3**
INV3 CEO acts as sounding board	2	1			1	1	1		1						1	**8**	**7**	**0.5**
INV4 CEO interacts with R&D to solve technical problems													1			**1**	**1**	**0.1**
INV5 CEO is involved in NPD			2		1			1	1		1				1	**7**	**6**	**0.4**
INV6 CEO holds frequent formalized meetings with R&D	1			1		1	1	1						1	1	**7**	**7**	**0.5**
INV7 CEO is involved at the start of an R&D project and then delegates it		1								1			1			**3**	**3**	**0.2**
INV8 CEO comes up with new innovative ideas							1						1			**2**	**2**	**0.1**
INV9 CEO evaluates economic viability of R&D project													3		1	**4**	**2**	**0.1**
INV10 CEO picks up to R&D innovational opportunities													1			**1**	**1**	**0.1**
INN INNOVATIVENESS																**1**		
INN1 CEO drives new product development in person									1							**1**	**1**	**0.1**
INN2 CEO takes control of every detail of NDP																**0**	**0**	**0.0**
INN3 CEO wants to transform/disrupt the market																**0**	**0**	**0.0**
CEO-OTH CEO OTHER THEMES																**130**		
CEO-OTH1 CEO admits limited knowledge in specific R&D area	1						1									**2**	**2**	**0.1**
CEO-OTH2 CEO admits not driving innovation but rather the direction of innovation																**0**	**0**	**0.0**
CEO-OTH3 CEO interacts with R&D only in those matters he/she has personal knowledge in														1		**1**	**1**	**0.1**
CEO-OTH4 CEO should not focus on technology	2									1					2	**5**	**3**	**0.2**
CEO-OTH5 CEO stresses the importance of strong knowledge in the field of innovation										1						**1**	**1**	**0.1**
CEO-OTH6 CEO requires R&D data to be simplified for strategic decision and communication	1	1	2	2	1	2			1	1	1	2	1	1		**16**	**12**	**0.8**
CEO-OTH7 CEO wants R&D to step out of academic thinking			1		1	2										**4**	**3**	**0.2**
CEO-OTH8 CEO role model is knowledge based										1						**1**	**1**	**0.1**
CEO-OTH9 CEO aims to obtain respect from R&D																**0**	**0**	**0.0**
CEO-OTH10 CEO attempts to understand R&D expertise			1	1	1	1										**4**	**4**	**0.3**
CEO-OTH 11 CEO carries R&D through difficult times																**0**	**0**	**0.0**
CEO-OTH12 CEO considers it an advantage to be untrained in science			1	1				1								**3**	**3**	**0.2**
CEO-OTH13 CEO considers himself at a disadvantage as a non-scientist																**0**	**0**	**0.0**
CEO-OTH14 CEO informs R&D about the company's position																**0**	**0**	**0.0**

CEO-OTH15 CEO role model is business driven							1	1								**2**	**2**	**0.1**
CEO-OTH16 CEO wants to protect R&D from the mundane aspects of running a firm		1				1										**2**	**2**	**0.1**
CEO-OTH17 CEO acts as a role model for innovation	1		1												1	**3**	**3**	**0.2**
CEO-OTH18 CEO role is to link R&D to internal & external stakeholders		1					1									**2**	**2**	**0.1**
CEO-OTH19 CEO reduces risk by fail fast fail cheap		1		2	1											**4**	**3**	**0.2**
CEO-OTH20 CEO gets information from/discusses R&D with all levels	1	2	1	1		1	1	1							1	**9**	**8**	**0.5**
CEO-OTH21 CEO role in R&D is not different from CEO role in non-R&D				1												**1**	**1**	**0.1**
CEO-OTH22 CEO looks for the best possible management team				2												**2**	**1**	**0.1**
CEO-OTH23 CEO requires persistence and resilience in LFSR				1								2				**3**	**2**	**0.1**
CEO-OTH24 CEO argues that innovation comes from top down and bottom up	1			1		2										**4**	**3**	**0.2**
CEO-OTH25 CEO and CSO are innovative forces together			1	1						1						**3**	**3**	**0.2**
CEO-OTH26 CEO innovates by challenging the organization (time, costs etc)					1			1								**2**	**2**	**0.1**
CEO-OTH27 CEO argues that innovation also occurs outside R&D	1	1			1				1							**4**	**4**	**0.3**
CEO-OTH28 CEO argues that R&D should always be one step ahead							1									**1**	**1**	**0.1**
CEO-OTH29 CEO educates the firm's environment													1			**1**	**1**	**0.1**
CEO-OTH30 CEO argues that value is as important as market													1			**1**	**1**	**0.1**
CEO-OTH31 CEO and R&D should have a relationship of trust and confidence	1				4			1				1				**7**	**4**	**0.3**
CEO-OTH32 CEO should have firm belief in the product												1				**1**	**1**	**0.1**
CEO-OTH33 CEO considers patients as innovation drivers												1			1	**2**	**2**	**0.1**
CEO-OTH34 CEO needs to understands process/risks of R&D														1		**1**	**1**	**0.1**
CEO-OTH35 CEO needs to understand culture of science														3		**3**	**1**	**0.1**
CEO-OTH36 CEO needs to know how to lead scientists														3		**3**	**1**	**0.1**
CEO-OTH37 CEO's understanding of scientists is more important than being a scientist														1		**1**	**1**	**0.1**
CEO-OTH38 CEO should have some basic understanding of science										1				1		**2**	**2**	**0.1**
CEO-OTH39 CEOs of LFRD firms should not be dominant											1			1		**2**	**2**	**0.1**
CEO-OTH40 CEO needs bottom-up ideas in LFSR firms									1					1		**2**	**2**	**0.1**
CEO-OTH41 CEO top scientist/top business man/women is ideal									1	1				1		**3**	**3**	**0.2**
CEO-OTH42 CEO argues that simple messages make for flawed decisions								1						1		**2**	**2**	**0.1**
CEO-OTH43 CEO – not R&D - should simplify the message														3		**3**	**1**	**0.1**
CEO-OTH44 CEO should make sure scientists can remain scientists (and not become managers)														1		**1**	**1**	**0.1**

CEO-OTH45 CEO should be very flexible														1	**1**	**1**	**0.1**
CEO-OTH46 CEOs should be/act transparent										1				2	**3**	**2**	**0.1**
CEO-OTH47 CEO can prevent a R&D knowledge gap by growing from within R&D														1	**1**	**1**	**0.1**
CEO-OTH48 CEO teaches R&D about business														2	**2**	**1**	**0.1**
CEO-OTH49 CEO does not need to be a scientist										1				1	**2**	**2**	**0.1**
CEO-OTH50 CEO has no time to talk to the scientists in R&D								1							**1**	**1**	**0.1**
CEO-OTH51 CEO balances R&D vision with the Board's vision												2			**2**	**1**	**0.1**
CEO-OTH52 CEO challenges R&D and is challenged by R&D										2			1		**3**	**2**	**0.1**
CEO-OTH53 CEO knows how to challenge R&D because of his experience										1					**1**	**1**	**0.1**

Nt: Number of times the concept or subtheme appears in the interviews; the number of times an a priori concept emerges during the interviews is presented in a shaded area; Ni: the number of interviews in which the theme appears; Ri: the ratio of Ni/Ntotal with Ntotal: the total number of interviews

Table 4-1 The appearance of themes during the interviews with CEOs

associated with the involvement at the start of the project after which it is delegated to the project team. The involvement of the CEOs is to make sure that the project starts with the required direction, boundaries and assumptions. Another subtheme INV8 'CEO comes up with new innovative ideas' was raised by 2 CEOs (7 and 13) who argued that they can be (and sometimes are) the source of new product development ideas which are then left to teams for further development. Subtheme INV9 'CEO evaluates economic viability of the R&D project' and INV10 'CEO picks up R&D innovational opportunities' are two new involvement themes.

Besides the new subthemes (ATI8, ATI9, COM8, INV7, INV8, INV9 and INV10) assigned to the major themes, a number of new themes emerged from the interview (CEO-OTH19 to CEO-OTH53) that were difficult to assign to one of the themes of attitude, attention, commitment, involvement or innovation. Some of them were carried from the pilot research into the final research (CEO-OTH1 to CEO-OTH16) but were not always addressed during the final CEO interviews (no number appears in the respective columns and rows), such as CEO-OTH2 ('CEO admits not driving innovation but rather the direction of innovation'); CEO-OTH9 ('CEO aims to obtain respect from R&D'); CEO-OTH11 ('CEO carries the scientists and their R&D through difficult times'); CEO-OTH13 ('CEO considers himself at a disadvantage as a non-scientist') and CEO-OTH14 ('CEO informs R&D about the company's position'). The new subthemes CEO-OTH17 to CEO-OTH53 are listed in Table 4-1 and are illustrated in Appendix H by means of quotes made by CEOs.

Distribution of subthemes

Table 4-1 presents the frequency of appearance of each subtheme for the a priori concepts (ATI1 ... INN3) and for the new roles or themes that emerged from the interviews (OTH1 ... OTH53). For example, the theme of attitude was mentioned by a majority of CEOs as a condition sine qua non for innovation to take place. The fact that a specified theme does not appear in the interview of a CEO ("0" in the table) does not mean that it is not considered important for that CEO, but only that under the given circumstances, he/she did not consider it worthwhile to refer to it. As was stated above, the main themes attitude, attention, commitment and involvement are addressed but the nature of underlying subthemes that support these concepts differ substantially among the CEOs.

For example, the subtheme ATI1 'CEO fosters a culture of innovation' appeared in 10 (Ni) out of the 15 interviews. The subtheme OTH28: 'CEO argues that R&D should always be one step ahead', was mentioned during one interview (Ni=1; CEO7). Other new subthemes also appeared only once such as the subtheme COM8 'CEO manages ideal cash flow' (CEO4). Of particular importance for this research is the identification of concepts or themes that are shared by all or most of the interviewed CEOs. Because the interviews took place separately and CEOs were not informed about each other's interview content, it is argued that when a theme is raised by all CEOs, the theme must have meaning for all CEOs concerned. This is discussed below under *Subtheme analysis*.

Further theme categorization

The discussion above analyses the data as they emerged from the interviews, i.e; without further sub-categorization. However, the data lend themselves to further categorization because a number of themes can be linked to each other. For example, some themes address the concept of 'knowledge' as seen from the perspective from the CEO and can be pulled together under the theme 'CEO knowledge'. They are listed below in the table (Table 4-2). In addition, other CEO- OTH themes can be categorized under the theme of 'CEO R&D knowledge complexity reduction, 'CEO Stakeholders', 'CEO Interaction at all levels', 'CEO Culture of science' and the 'CEO Challenger'.

Knowledge. Knowledge is recognized as a central theme by the CEOs and although involvement is a knowledge based conception of the role of the CEO, the references made by the CEOs to 'knowledge' are different from the 'knowledge' that was the basis for the creation of the concept of involvement. While the concept of involvement requires intricate knowledge of either the process and the science that supports the R&D activities, the references to knowledge in CEO-OTH1, 3, 5, 8, 10, 12, 34, 38, 47, 49 and 48 address the concept of knowledge as the source of potential conflict, a problem or as a vague point of view, e.g. the presence of limited knowledge (CEO-OTH1), the interaction with R&D only in those matters in which the CEO has knowledge (CEO-OTH3), the emphasis on the need for knowledge (CEO-OTH5 and 34), the differences in CEO opinion whether or not knowledge is actually required (CEO-OTH12, 38, 49), the general statement that the CEO role model is knowledge based without further specification (CEO-OTH8) and the accumulation of new knowledge either through R&D experience (CEO-OTH47) or through attempts to understand it (CEO-OTH10) and finally the exchange of knowledge through teaching (CEO-OTH48). In other words, although CEOs refer frequently to different knowledge related themes, when taken together they do not constitute a homogeneous major theme as there is no agreement amongst them about the need for knowledge to run a life science R&D firm.

R&D knowledge complexity reduction. The theme of data simplification (CEO-OTH6) and the observation by CEO14 that it is the CEO who should conduct the de-complexification step (CEO-OTH43) are categorized in the theme of CEO 'R&D knowledge complexity reduction'. This theme was also observed in big pharma firms (CEO11 and CEO12).

Stakeholders. Because CEOs have to take care of all stakeholders of the firm, a separate category is created as 'CEO Stakeholders' that includes the themes CEO-OTH18, 21 and 59.

Interaction at all levels. Some CEOs interact with R&D at all levels within the company and CEO-OTH20, 40 and 24 illustrate that attitude.

Culture of science. CEO14 has clear views on the need for leadership of scientists as is clearly articulated by the themes CEO-OTH35, 36, 37 and 44 illustrating the need to

Further CEO theme categorization																			
	CEO1	CEO2	CEO3	CEO4	CEO5	CEO6	CEO7	CEO8	CEO9	CEO10	CEO11	CEO12	CEO13	CEO14	CEO15	Nt	Ni	Ri
CEO Knowledge	1		2	2	1	1	1	1	0	3	1	0	0	3	4	**20**	**14**	**0,9**
CEO-OTH1 CEO admits limited knowledge in specific R&D area	1						1									2	2	0.1
CEO-OTH3 CEO interacts with R&D only in those matters he/she has personal knowledge in														1		1	1	0.1
CEO-OTH5 CEO stresses the importance of strong knowledge in the field of innovation										1						1	1	0.1
CEO-OTH8 CEO role model is knowledge based										1						1	1	0.1
CEO-OTH10 CEO attempts to understand R&D expertise			1	1	1	1										4	4	0.3
CEO-OTH12 CEO considers it an advantage to be untrained in science			1	1				1								3	3	0.2
CEO-OTH34 CEO needs to understands process/risks of R&D														1		1	1	0.1
CEO-OTH38 CEO should have some basic understanding of science										1				1		2	2	0.1
CEO-OTH47 CEO can prevent a R&D knowledge gap by growing from within R&D															1	1	1	0.1
CEO-OTH48 CEO teaches R&D about business															2	2	1	0.1
CEO-OTH49 CEO does not need to be a scientist											1				1	2	2	0.1
CEO R&D knowledge complexity reduction	1	1	2	2	1	2	1		1	1	1	2	1	4		**20**	**13**	**0,9**
CEO-OTH6 CEO requires R&D data to be simplified for strategic decision and communication	1	1	2	2	1	2			1	1	1	2	1	1		16	12	0.8
CEO-OTH43 CEO – not R&D - should simplify the message														3		3	1	0.1
CEO Stakeholders		1					1						3			**5**	**3**	**0,0**
CEO-OTH18 CEO role is to link R&D to internal & external stakeholders		1					1									2	2	0.1
CEO-OTH51 CEO balances R&D vision with the Board's vision													2			2	1	0.1
CEO-OTH29 CEO educates the firm's environment													1			1	1	0.1
CEO Interaction at all levels	1	2	1	2		3	1	1	1					1	1	**14**	**10**	**0,1**
CEO-OTH20 CEO gets information from/discusses R&D with all levels	1	2	1	1		1	1	1							1	9	8	0.5
CEO-OTH40 CEO needs bottom-up ideas in LFSR firms									1					1		2	2	0.1
CEO-OTH24 CEO argues that innovation comes from top down and bottom up	1			1		2										4	3	0.2
CEO Culture of science														8		**8**	**1**	**0,1**

CEO-OTH35 CEO needs to understand culture of science														3		3	1	0.1
CEO-OTH36 CEO needs to know how to lead scientists														3		3	1	0.1
CEO-OTH37 CEO's understanding of scientists is more important than being a scientist														1		1	1	0.1
CEO-OTH44 CEO should make sure scientists can remain scientists (and not become managers)														1		1	1	0.1
CEO Challenger					1			1			3			1		**6**	**4**	**0,3**
CEO-OTH26 CEO innovates by challenging the organization (time, costs etc)					1			1								1	1	0.1
CEO-OTH52 CEO challenges R&D and is challenged by R&D											2			1		3	2	0.1
CEO-OTH53 CEO knows how to challenge R&D because of his experience											1					1	1	0.1

Table 4-2 Further theme categorizations from CEO interviews

understand the culture of science, how to lead scientists and the fact that CEOs should make sure scientists can remain scientists (and not become managers).

Challenge. Finally, the CEO is also a challenger as exemplified by the themes CEO-OTH26, 52 and 53. However, these types of challenges are not part of the involvement theme in which 'challenger statements' are also included such as INV1 and INV2. The difference is that in INV1 and in INV2 these challenges specifically address the R&D function, while in CEO-OTH26, 52 and 53, they address the reciprocal challenge CEO-R&D which is different from the involvement of the CEO *in* R&D, the challenge of the firm activities with respect to time and costs (i.e. operational challenges at firm level) and the CEO's capability to challenge (which is different from actual challenging) respectively. Therefore, these themes were not included under the a priori theme of involvement (INV) but treated as separate themes.

Subtheme analysis

When the data presented in Table 4-1 are analyzed further according to the frequency by which they appeared during the interviews (Ni, max = 15, theme emerges in all interviews; min = 0, theme does not emerge in an interviews), the following observations can be made. The theme COM6 'CEO creates … structures for innovation' appears in 12 of the 15 interviews (with CEO1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14 and 15). It implies that the majority of the CEOs are committed to creating organizational structures for innovation to take place, such as flat and matrix organizations. The use of flat & matrix organizations is a common approach in life science R&D firms seen the requirement for diverse experts to become part of R&D project teams and it is therefore not surprising that this theme appears in a majority of interviews. The theme ATT2 'CEO sets the focus and boundaries in which innovation to take place' appears in 13 of the 15 interviews. Figure 4-1 shows the number of interviews (Ni) in which these themes emerge (ATI1 to CEO-OTH53).

Other literature based a priori themes that appear frequently are themes that refer to (in decreasing order):

- the setting of the direction and vision (ATT1; 12/15),
- external collaboration (ATI5; 11/15),
- the fostering of a culture of innovation (ATI1; 10/15),
- the selection and hiring of innovative leadership (COM1; 7/15),
- CEO challenges R&D for efficiency (INV1; 7/15),
- CEO holds frequent R&D meetings (INV6; 7/15)
- CEO acting as a sounding board (INV3; 7/15),
- the acceptance of experimentation and failures (ATI2; 6/15),
- the fostering of internal communication (ATI3; 6/15),
- the exchange of diverse ideas (ATI4; 6/15),
- the incentives and rewards for the R&D function (COM2; 6/15),
- CEO is involved in NPD (INV5; 6/15)

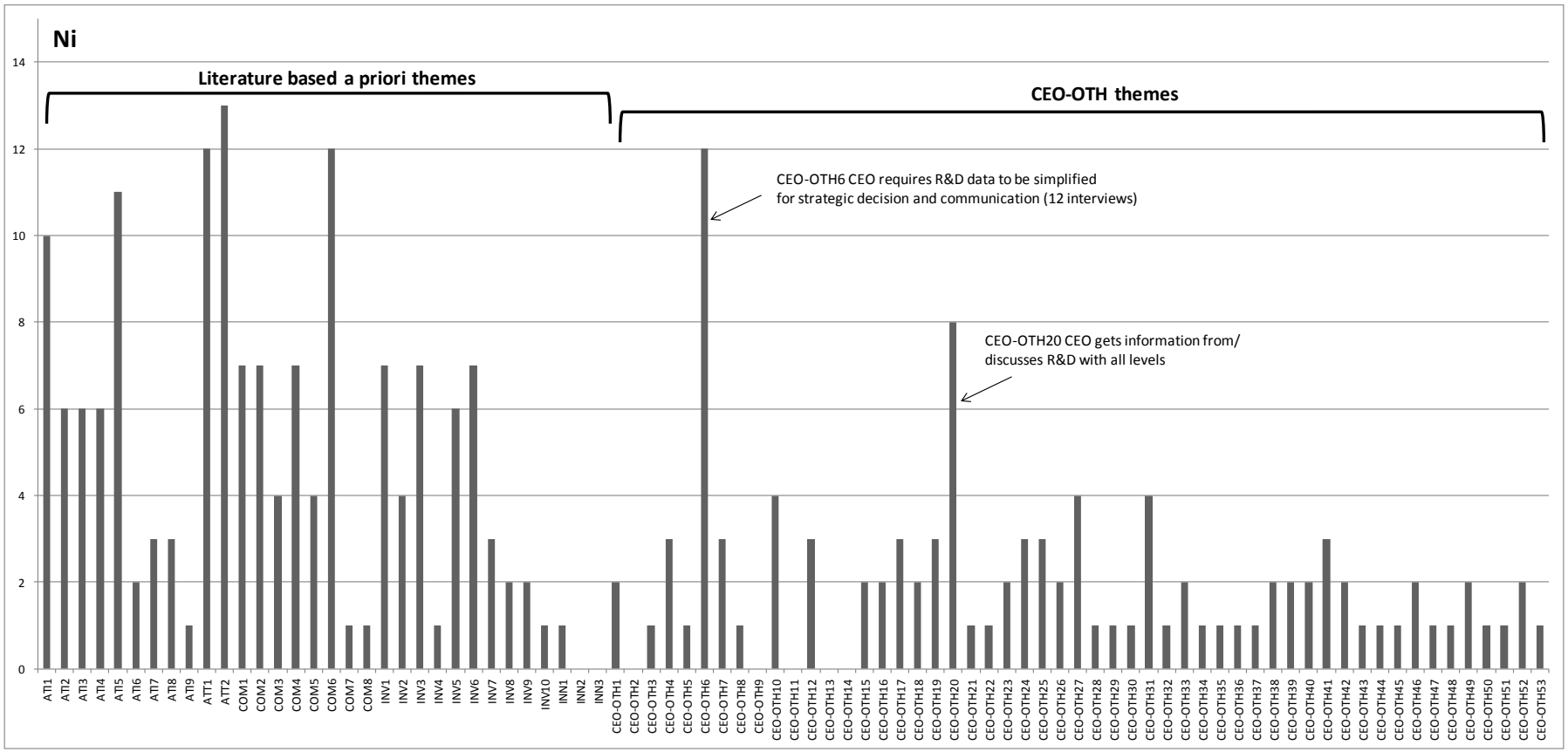

Figure 4-1 Distribution of individual subthemes emerging during 15 CEO interviews

This overview is not unexpected as the different subthemes are intrinsically linked to each other: the creation of an innovative organization proceeds through the setting of direction and focus, the fostering of a culture of innovation through acceptance of experimentation and failure, internal communication through frequent R&D meetings and exchange of diverse ideas, selection, hiring, incentivizing and rewarding of innovative leadership (Goffin and Mitchell, 2011). In view of the fact that the firms selected for this research are limited in size and therefore allow frequent interaction between the top of the organization and the lab-bench, the subtheme of 'CEO acts as a sounding board' (INV3; 7/15) is also not unexpected. Therefore, the CEO-OTH20 theme of 'CEO gets information from/discusses R&D with all levels' is not surprising either (see Figure 4-1).

However, one could have expected that the CEOs, because of the limited size of the firms and the possibility of frequent interactions with R&D, would not raise a theme referred to as the 'requirement for simplification of R&D data for strategic decision and communication' (OTH6). This theme of 'R&D simplification' was mentioned in 12 out of the 15 interviews and was emphasized strongly during the interviews (Nt 16; see Table 4-1). It was raised as an important part of their job and it was observed independently of their educational status, prior expertise or tenure. The theme was unexpected and differed from the other subthemes that appeared in the interviews in that the latter are well known innovation concepts (i.e. culture of innovation and structures for innovation etc.). It was observed that the CEOs do not take strategic decisions based upon raw data but on a knowledge base that was transformed – either by R&D, by discussions within the TMT or through an individual appointed to perform this task – into a package that is amenable to challenge and decision making. In the case of CEO1 for example, he/she argued that he/she expects his R&D head to take the 'learnings of the TMT with respect to the business proposition' back in the laboratories to make the decision process at the level of the TMT more efficient. This process of transfer of R&D knowledge whereby the data are being transferred from one context to another in order to make it useful for the CEO to discuss, challenge and take decisions was a recurring theme in the interviews. The separation between the CSO – as the 'scientific superstar' – and the CEO as the 'direction giver' is raised by many CEOs. It is accompanied by the observation that – because of the complexities of modern life science R&D – CEOs are not capable anymore to fully grasp the intricacies of the scientific activities conducted in their firms even when they were trained as a scientist. CEO2 argues that – even with his scientific background (he holds a medical/biological science doctorate) - it is impossible to understand the intricacies and complexities of current R&D. In line with CEO1's observation, CEO2 requires the R&D teams to re-contextualize their know-how. CEO2 considers this an important aspect of R&D management and calls this process 'complexity reduction'. According to CEO2, this is required for two reasons: first, it makes the R&D know-how ready to be challenged by the CEO at the same level of challenge as the challenge that is given by the CEO to other company functions (finance, IP). Second, the simplified data can be used as a business proposition to be discussed with the top management team and with outside stakeholders (such as investors). This complexity reduction is a process

whereby R&D know-how is transferred into language that the CEO is able to challenge so that...

*'I cannot be fooled' (*CEO2*).*

According to CEO2 the process of complexity reduction is a bimodal concept because it is not only important to allow appropriate challenging and to make strategic decisions but also to serve the whole company, its shareholders and its internal/external stakeholders. The simplified R&D know-how 'should not only make sense' to the CEO but should also be the basis for 'story telling'. It means that the complexity reduction process serves the 'story telling' activity about the firm and its scientific assets. According to CEO2, the story telling and the associated internal and external communication is one of his/her responsibilities in a life science R&D firm.

CEO4 admits that he is not capable to understand the 'lyrics' of R&D (he holds an MBA and has no scientific background), but is capable of appreciating the 'music':

> '*I do not understand the science so I cannot go into the details of the science but I know what the key projects are and I try to understand what is going on. I always say that I want at least to understand the music. I don't understand the lyrics but I need to understand the music and I need to be able to challenge and then I will challenge (*R&D*) people. That is the approach'*

The 'music-lyrics' metaphor is explained as follows. The 'lyrics' that CEO4 is referring to, is the raw R&D data consisting of biotechnological vocabulary that is only open for assessment, evaluation and discussion by experienced R&D researchers. These scientific 'lyrics' are incomprehensible for CEO4 and in order for him to make sense of the data, he requires them to be communicated, not through the 'score or the text of the piece of music' but through its essence: the music itself. This 'music' can be appreciated or criticized by anyone, even by those who do not understand the lyrics or the score. Reducing the score and the lyrics of a piece of music to the actual music (what is heard) is – fundamentally - a process of complexity reduction. During his interactions with R&D, CEO4 wants to understand the basics of the science that takes place in the firm, as to make up his mind whether or not this 'makes sense'.

The interviewed CEOs seem to be capable to extract from a set of complex pieces of knowledge that specific information that is important for them to make strategic decisions on the condition that the knowledge from R&D undergoes a transformation to allow the CEOs to do so. For the CEO to be able to grasp the knowledge that is generated in the R&D department, this knowledge needs to be calibrated to the level of the CEO. What seems to take place is an equilibration whereby the knowledge levels of both parties, the CEO and R&D, find a common base that, on the one hand, retains the core of the message that R&D wants to see conveyed and, on the other hand, allows the CEO to use his prior knowledge and experience to challenge it. It seems that the prior

knowledge of the CEO (either obtained through education or through experience) drives the calibration of the message from R&D down to the level of the CEO such that he/she can challenge and evaluate it. Even CEOs with a strong educational science background require a de-complexification step seen the pace by which science evolves and the speed by which a CEO's knowledge is out-dated if he/she is not actively involved in the science. Because the concept of complexity reduction strongly emerges from the interviews and because the majority of the CEOs agreed on its importance, the interview transcripts were re-analyzed and the quotes made by the different CEOs compared against each other. This is the topic of the next paragraph on interview observations.

4.2.2.2 Interview observations

Key interview observations are available in Appendix I. It presents a detailed discussion of interview observations during the CEO interviews with a focus on R&D knowledge complexity reduction. A table summarizing some of the quotes is introduced in the table below.

CEO	Conversation on complexity reduction: quotes on complexity reduction of R&D knowledge
CEO2	'*I think the other key thing is to be able to reduce this complexity to simple idea...'*
CEO3	*'...if you can't translate a technical issue to a common sense business language discussion and really have a discussion on the principles, on the core of what is really happening there then either – you know - there's a communication gap or you don't fully understand really what's behind it....they need to take that one extra step of translating a technical conversation to a common sense conversation but I think in going through that effort you end up having a much deeper discussion ... I think you have a much more robust discussion if you're able to translate the scientific point to a common sense point...'*
CEO4	'*I do not understand the science so I cannot go into the details of the science but I know what the key projects are and I try to understand what is going on. I always say that I want at least to understand the music. I don't understand the lyrics but I need to understand the music and I need to be able to challenge and then I will challenge (*R&D*) people. That is the approach'*
CEO5	'*..break it down to the most simple common denominator, simplest form of the issue, so yes you can get bogged down into this miniature but I always try to keep it in a very simple form, simple is better for me right always and so I tend to probe in a very simplistic way and try to get to the most simple explanation, essentials ... I try to say: if you were talking to your 10 year old son how would you explain what you're doing, what you're trying to do..." .... "you know if you're going to a warm buffet and meet someone who doesn't understand anything about science, how would you get that person to invest in your company by simplifying what you're trying to do?*'
CEO6	*'...it only develops by practicing is that we're able to simplify the problem or the story to the essence so that we can look at it from a business point of view so that we can look at the business case and yes this role is extremely complex but if you ask the right questions I think you can simplify it to a certain level that you can make your decisions'* *'...so one of the things I learned is don't try to download your complexity on your boards because then they go bananas but we're also training the scientists to not download all their complexity on the leadership team'*
CEO7	*'at one time in the future, the chief scientist will know much more than I do and it is he who will then need to simplify the data, the same way as I am currently transferring simplified data to the board'*
CEO8	*'...our chairman knows more about the science than I do, there is no need to simplify the data or reduce the complexity of the science I am putting on the table at the board'*

CEO9	*'I'm involved with people that are doing bioinformatics, who have to simplify what they are discovering to me... but they have to make clear to me what they have found and how they came to that process in very general terms that I understand so ... I always want to understand it... bring it (*the R&D knowledge*) into convincing digestible pieces of knowledge...'*
CEO11	*'Look ... you probably need both kinds of people, very strong in the science but maybe not that good in communicating on what they are doing and trying to translate that into what I would call normal language that is: such that the marketing guy will understand, the CFO can understand and other people can understand what this really means...'*
CEO12	*'... well I'm a chemist by training so they cannot really catch me totally off guard, so ask silly questions, make them explain and ask, ask, ask, if you come to the fifth why usually you get an answer that even you understand, that even I understand.. what I want to understand is whether it's thought through and that there is a high conviction level of the fact that we're doing the right thing, I want to test this identification, this belief, emotional bond which is often thought through, well thought through...'*
CEO14	*'by simplifying things you induce another variable (in the decision making process), the more variables you have to deal with the more difficult the decision will be and so the outcome becomes unpredictable. Simplification does not remove the variables ... they don't disappear by this simplification'* *'... I think its up to the CEO to do the reduction... it's not up to the scientist, it's up to you as CEO whether you can live with that...'*

Table 4-3 Some quotes by CEOs on the topic of reduction of R&D knowledge complexity

4.3 CEO focus group

The findings of the focus group research are tabulated in Appendix K and represent the main phases of interaction among the 4 CEOs. In general, there were no topics on which the CEOs formally disagreed. All CEOs reaffirmed the themes that emerged during their individual interviews and during the interviews with their colleagues. Again, the concept of CEO innovativeness was not addressed. CEO5 reconfirms the a priori literature concept of 'attention' by referring to the concept of 'focus' but argue that focus is difficult, seen the caliber of the scientists working in R&D. This is a re-confirmation of the statement made by CEOs (see CEO-OTH4 above) that the focus is on maintaining the firm's competitive edge, and not allowing R&D to explore non-core academic routes. Although not explicitly raised during the individual CEO interviews, CEO15 raises the topic of 'R&D motivation' and argues that it may be improved/ supported through a culture of transparency that in turn generates commitment from R&D. CEO5 argues that CEO commitment has its counterpart in R&D commitment. Although it is premature to argue, this is an interesting idea in that a CEO role behavior such as attitude etc. may require its R&D equivalent in order for innovation to flourish, such that CEO commitment triggers R&D commitment and vice versa. In addition CEO5 stresses the 'learning agility' as compared to the 'learning ability' of the CEO. According to CEO15, 'dis-involvement' in the science by the CEO is useful in order to create a clear vision for the future and to create some distance from the science. The need for CEO knowledge cannot be agreed upon among the CEOs. While CEO5 argues that it is not required to have an understanding of the science, CEO8 is convinced that if the CEO does not have knowledge of the scientific principles supporting R&D, 'you have an issue'. In other words, the concept of the need for 'knowledge' remains a discussion topic among CEOs (and among R&D executives as well, as will be seen in Chapter 5).

CEO5 reconfirmed the statement made during the individual interviews in that the complexity reduction of R&D knowledge allows the CEO to develop a narrative such that story telling inside and outside of the firm can take place. In addition, CEO15 argued that the complexity reduction step is crucial in that it allows to focus the R&D function on the objectives of the firm's R&D. By becoming too much emerged in 'raw R&D', the risk exists that the R&D function looses focus and becomes involved in the science and technology itself, drawn as they may be into interesting (but commercially useless) scientific opportunities. This was one of the major concerns of the CEOs, i.e. that either themselves or the R&D function 'falls in love with the science and technology'. By creating a version of their research from which the complexity is removed, the CEO is capable to use this 'simplified' version to focus R&D and to rally the whole firm behind the idea (CEO5). This message becomes embedded in their mind and allows them – as well as the CEO – not to become sidetracked from the major R&D objective. The complexity reduction of R&D knowledge therefore is – according to these 4 CEOs - a necessary step to focus R&D. The comments made by CEO5 and CEO15 show the importance of the concept of complexity reduction and it seems to be an important instrument in the CEO's arsenal of management techniques to manage his/her firm. This was corroborated by all CEOs present in the focus group. CEO dominance was also referred to as a CEO characteristic that is incompatible with the management of life science R&D firms as corroborated by CEO14 during the individual interviews.

4.4 Discussion

4.4.1 Literature based themes

The findings have showed that the concepts retrieved from the literature on the role of the CEO in innovation, i.e. attitude, attention, commitment and involvement in different industrial settings can also be found in life science R&D firms and this is illustrated in Figure 4-2. The figure presents the themes that emerged from the interviews together with the number of times (i.e. the weight (Krippendorf, 2013) by which) they emerged from the interview transcripts (Nt in Table 4-1). The literature based a priori themes are introduced as shaded boxes. As can be seen, the concept of the CEO as innovator (innovativeness) was not supported by the CEOs: they do not consider themselves as the drivers of breakthrough and/or disruptive innovations but rather as facilitators of innovation. Only one CEO (CEO-founder, CEO9) referred to this theme and considered him/herself the driver of breakthrough innovations:

'*Who is the main (product) innovator in the firm? I am*'

The low emergence of CEO innovativeness stands in contrast with the innovativeness of CEOs in high-tech design and IT firms where the CEOs are recognized as innovators (Dickson et al. 1995). The concept of CEO innovativeness, as a CEO 'who has original ideas, would sooner create something new than improve something existing and often risks doing things differently', as defined by Thong and Yap (1995), is not observed in

these life science R&D firms. The frequency with which each concept is addressed by the CEOs varies. For example, attitude and commitment are more frequently mentio-

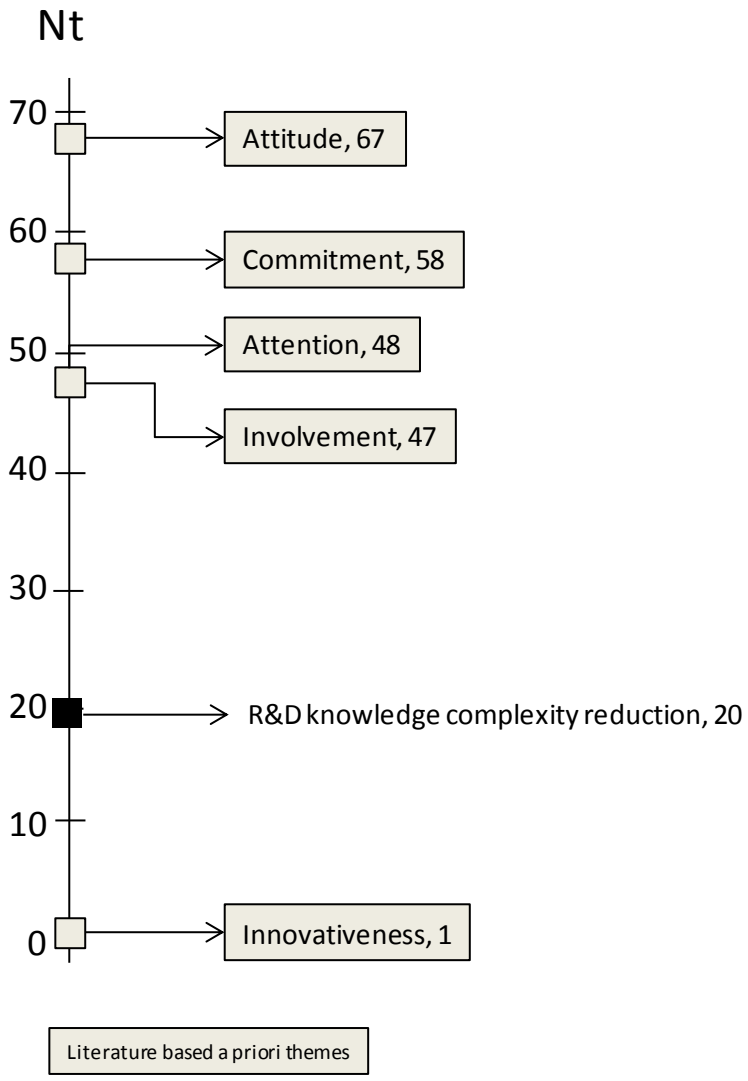

Figure 4-2 Ranking themes according to their emergence during interviews of CEOs

ned by the CEOs than involvement and attention. Although the evaluation of qualitative data using quantitative data should be done with utmost caution because

> 'it is probably most important to keep their Janus-faced character in mind' (Krippendorff, 2013),

the fact that CEO attitude is on top of the ranking is not surprising as it is also recognized and supported by previous research reported in the literature (Chapter 2). For example, Damanpour and Schneider (2006) showed the importance of attitude towards innovation of the top manager in governmental organizations while Papadakis and Bourantas (1998) found attitude to be critical in driving innovation in high technology

firms. The theme of CEO commitment (i.e. making available human and financial resources, see chapter 3) is not unexpected seen the considerable cash burn in these life science R&D firms. The emergence of attention and involvement as a potential driver of innovation is corroborated by Yadav et al., 2007 in the banking industry and by Laforet and Tan (2006). The presence of CEO involvement as a driver of innovation is corroborated by findings by Dickson et al. (1995) who found CEO involvement to be important in innovation in design firms. This is probably caused by the fact that the knowledge gap between CEO and the R&D function in these firms is lower (although this is a statement not supported by empirical evidence) while there is a clear knowledge gap between the CEO and the R&D function in these LSRD firms, as clearly argued by CEO3:

'*there is a gap, right?*'

Concluding that the concepts of attitude and commitment to innovation are more accurate role descriptors for CEOs in life science R&D companies than involvement and attention is not possible because the qualitative study was not designed to uncover differences in the level of appearance of conceptual roles but rather to ascertain whether they could be observed in life science R&D firms. A more in-depth interview and longer term observation of the CEOs may lead to convergence of the concepts and to a more stabilized pattern in which concepts are addressed in more or less equal measure. In summary, the answer to the first research question whether the a priori concepts from the literature appear in the context of life science R&D firms can be confirmed with the exception of the role of the CEO as innovator.

These a priori role concepts as stated by the CEO are not necessarily perceived as such or required by the R&D function. For example, it may be that CEOs are involved in R&D but it is not clear whether this has a positive impact upon the R&D workforce's performance or innovative work behavior. The R&D function may require other conceptual roles from the CEO than those which are discussed above. In other words, there may be misalignment between the CEO's a priori roles and the roles as *perceived* or *expected* by the R&D function. This will be explored in Chapter 5.

4.4.2 New themes

The second research question addressed the appearance of other (new) themes or concepts that emerge during the interview. Besides the literature-based themes of CEO-attitude, -attention, -commitment and –involvement, CEOs describe their role of innovation using a myriad of other themes, indicating that the role of the CEO is still much unexplored and that the use of CEO proxies such as CEO age, CEO tenure etc., as employed in upper echelon research, provide a rather limited view on the role of the CEO. The data show that CEOs use a myriad of other themes that can be used to describe their role (Table 4-1). The themes were divided in 6 groups pointing to:

- CEO Knowledge
- CEO R&D knowledge complexity reduction

- CEO Stakeholders
- CEO Interaction at all levels
- CEO Culture of science
- CEO Challenge

and a number of other (granular) themes that were difficult to put into new major themes or categories.

It is no surprise that the CEOs consider themselves as key in involving firm stakeholders, either internal or external to the firm. It also comes as no surprise that CEOs argue that they interact with different hierarchical levels in the firm. This observation is the result of the size of the firm (the selected firms were SMEs) and because CEOs have created flat hierarchical structures (see COM6; Ni 12; Ni 15). The big-pharma CEOs did not make this observation because they are not in a position to approach the different levels seen their firm's size. In addition, CEOs are known as challengers and this also emerges from the interviews. Few CEOs argue that there are specific leadership skills required to lead science based firms such as the understanding of the culture of science, or that it is more important to understand the culture of science than being a scientist oneself. These comments were raised by the CEO who was thoroughly trained academically (two doctorates in biomedical sciences and a MBA) complemented with extensive experience in leading science-based firms.

CEOs made it clear that knowledge is an important concept and discuss this along the need for knowledge complexity reduction. The majority of the CEOs made it clear that R&D knowledge is subject to a process of 'complexity reduction' before it is transferred to a higher echelon in the organization for use in strategic decision making and/or communication. The one exception in this regard is CEO8, who did not agree with the 'simplification' or 'complexity reduction' step because it was argued that this may lead to flawed decision making processes (see Appendix I). One of the major differences with the other companies is that the board of the company that is run by CEO8, consists of three individuals: CEO8, the chairman and an academic representative. The chairman of the board is fully aware of the intricacies of the science that is conducted in the firm and therefore does not require any complexity reduction step. In other words, there seems to be a 'knowledge continuum' between the R&D labs, the CSO, the CEO and the board. In the other firms, the CEOs reported into boards whose members were scientifically educated but whose careers took off in positions where extensive experience in commerce, investment banking, licensing/business develop-ment, project management was accumulated. However, they lacked expertise in the areas of R&D in which the firms were involved. In order to convince the board, the R&D message could not be transferred as such from the laboratories unless the board "would go bananas", as CEO6 put it (see Table 4-3 and Appendix I). This process was described by one of the CEOs as a process whereby the R&D function needs to put its knowledge into the context of a business proposition. The data hereby takes a new form that makes it amenable to challenge by the CEO and the TMT and forms the basis for strategic decision making. This process of transfer of knowledge from one organizational unit to another one is a

process whereby data are moved from one context (the R&D function, with its own vocabulary, procedures and routines (Styhre, 2009)) to another context (the TMT) and therefore is essentially a process of re-contextualization. This need for re-contextualization of R&D knowledge was illustrated by the CEOs in their concern that the company's R&D activities focus too much on the technology itself whereby the R&D function would conduct research for the sake of scientific progress instead of being driven by market potential. CEOs play a role in innovation by attempting to bridge the knowledge gap with R&D and by reducing its complexity and re-contextualizing its content.

In Table 4-2, it is clear that CEOs consider knowledge an important element in leading their firms. They do not agree however how much of this knowledge is required. As an example, CEO4 (he/she holds a MBA from a reputable business school) argues that because he/she does not understand the R&D knowledge he is able to ask the right *questions*, while CEO8 (an engineer with extensive consulting experience in a reputed consulting firm) argues that because he/she understand the R&D knowledge he is able to take the right *decisions*. In other words, while the CEOs do not agree on the level of knowledge they require in order to be able to absorb the knowledge from R&D, the majority of the CEOs agree that there is a need to reduce the complexity of the knowledge of R&D to make strategic decisions. This is an unexpected finding and therefore deserves further discussion.

4.4.3 From complexity reduction to CEO absorptive capacity

The process by which R&D knowledge is transferred to the CEO (and further on to the board) is a process of complexity reduction to make sure that the complexity is not 'downloaded' to the CEO (see Table 4-3; CEO6). It was argued that this is an unexpected finding in these firms because of their small size but it was also found in big pharma. In other words, it seems to point to a generalized characteristic of a CEO's role in innovation in life science R&D firms. As CEO6 and CEO3 argue:

> *'... we're training the scientists to not download all their complexity on the leadership team ... they're forced to crystallize the research reality along answers to simple questions'*

> *'....they (R&D) need to take that one extra step of translating a technical conversation to a common sense conversation ... in going through that effort you end up having a much deeper discussion'*

The reduction of the complexity needs to take into account the prior knowledge of the CEO. In the case of the CEO accountant (CEO2P, to take the most extreme example, see Appendix E), the knowledge had to be transformed by two hired consultants in order for CEO2P to understand the knowledge. In other words, the knowledge had to be titrated down to the level of the ability of the CEO to absorb the new knowledge from R&D. Cohen and Levinthal argue 'that the ability to evaluate and utilize outside knowledge is largely a function of the level of prior related knowledge. At the most elemental level,

this prior knowledge includes basic skills or even a shared language but may also include knowledge of the most recent scientific or technological developments in a given field' (Cohen and Levinthal, 1990). Cohen and Levinthal argue that an organization's absorptive capacity, i.e. 'an organization's ability to evaluate and utilize outside knowledge will depend on the absorptive capacities of its individual members' and thus – even more critically - on the absorptive capacity of the CEO as the final decision maker. Therefore the theme of the complexity reduction observed during the content analysis of the CEO interviews, points to the CEOs' individual absorptive capacity. As a result, it is argued that the CEO's absorptive capacity is a new major theme. While the CEOs never raised the theme of CEO absorptive capacity themselves, they inferred its existence through their clearly articulated need for complexity reduction.

4.4.4 From complexity reduction to R&D focus

The focus group research was to inquire how CEOs, when brought together, respond to the conclusions of the research conducted in the first part during the individual interviews. Doing so, this research acts as a validation instrument to evaluate whether the observations made by the interviewer sound familiar with the CEOs and whether any of the comments raised by themselves generate new ideas or themes that would give additional clarification of their roles in innovation. The importance of the concept of complexity reduction was not only recognized by the CEO focus group but was also strengthened and put into a different perspective. While the concept was originally identified as an exercise that took place to equilibrate the knowledge levels between CEO and R&D in order for the CEO to be able to value the knowledge, it was now strengthened in that complexity reduction is also used to 'sell the idea to the shareholders, to the market and to the employees' and - as argued by the CEOs - to force R&D to focus on what it is actually doing. In other words, complexity reduction is not only an exercise of straightforward simplification in order for the CEO to understand what is 'going on', it also serves the focus of the project by R&D and the valuation (or perception of the value) of the project by other stakeholders. Doing so the CEO 'returns' the simplification back to the R&D executives in that he/she uses the simplified message to keep the scientists within focus as to prevent them to distract and wander into interesting academic opportunities that do not contribute to the firm's innovational strategy (according to the CEOs, a 'nightmare'). CEO8 who argued during his/her individual interview that the process of complexity reduction was not required in his firm, agreed with this interpretation of the use of complexity reduction as an instrument of focus. According to CEO15, it is also a training exercise for the CEO, in that he/she learns to ask the right questions, to challenge R&D and to generate motivation within the R&D team because he/she is only capable to drive the company only if he/she understands the science that is taking place. In other words, the CEOs use this complexity reduction to focus – manage – the R&D function. The concept of R&D focus was not identified as a new theme in its own right as it is a constituent of the literature based theme of 'attention' (see Chapter 2). However, the process of complexity reduction shows how CEOs without prior knowledge of R&D are still able to focus R&D.

Although this research project offer some insight into the role of the CEO in innovation in life science R&D firms, a number of questions remain unanswered. For example, are these CEO role behaviors, as stated by the CEOs, also perceived by the R&D executives and do R&D executives perceive the same CEO role behaviors or do they observe other behaviors from their CEOs? The next part of the research project attempts to answer these questions.

4.5 Summary

The concepts retrieved from the literature and used to research the role of the CEO in innovation in other industrial settings, i.e. attitude, attention, commitment and involvement are also found in life science R&D firms. Through their positive attitude towards innovation, their attention to the future and the resources they make available, CEOs facilitate the innovation in their firms and become involved in R&D. CEOs are not innovators: they do not consider themselves as the drivers of breakthrough and/or disruptive innovation. In order for CEOs to play a role in innovation, they need to make considerable use of their absorptive capacity. R&D reduces the complexity of its knowledge and titrate it to the level of the CEOs' absorptive capacity. The CEOs argue that this reduction of complexity is also used to keep the R&D function focused on their objectives and to keep it aligned with the firm's objectives such that it does not deviate from the firm's innovational objectives by exploring scientific projects which are not commercially interesting. A tabular overview of the findings is presented in Table 4-4.

	Themes addressing the role of the CEO in innovation as they emerged from individual structured interviews of CEOs					
	A priori themes from the literature					**New theme**
	ATTITUDE	**ATTENTION**	**COMMITMENT**	**INVOLVEMENT**	**INNOVATIVENESS**	**CEO ABSORPTIVE CAPACITY**
CEO	+	+	+	+	–	+

Table 4-4 The a priori themes and new themes observed during the CEO interviews

Based on these observations at this stage of the research, the role of the CEO can be described as follows:

'The CEO leads innovation in life science R&D firms by making considerable use of his/her absorptive capacity. This allows him/her to bridge the knowledge gap with the R&D function and to focus the R&D function without the need to fully understand the

intricacies of the science driving the innovation'. In order to further substantiate these findings we now turn to the view of the R&D function on the CEO's role in chapter 5.

5 Findings - the role of the CEO as seen by R&D

5.1 Introduction

The second part of this research continues the exploration by focusing on the role of the CEO but now seen through the lens of senior R&D executives. As was observed in the literature review on the role of the CEO in innovation, it was found that the R&D function - because of its autonomy, competitive knowledge and resistance to managerial leadership and practice - is capable to take the firm in a new strategic direction and hence possess power that is usually observed (and expected) to reside with the top manager. Seen this power, it would be interesting to explore how the R&D function sees the CEO in his/her role in innovation. For example, if CEOs argue that they offer direction to firm innovation, how does the R&D function perceives this direction setting? Does R&D accept such direction from top management? Does it accept and even expect the CEO to do this? This chapter presents the results of an investigation of the perceptions of 39 senior R&D executives (6 pilot and 33 final) about the role of their CEO in innovation. It proceeds as follows. First, in Section 5.2., an example interview is given (5.2.1.) followed by the findings of the final interviews (5.2.2.) which are divided in 2 parts: the content analysis of the interview transcripts in 5.2.2.1. and interview observations in 5.2.2.2.. The data are discussed in 5.3. and summarized in 5.4.

5.2 R&D interviews

5.2.1 Example interview

This section presents an example interview of a R&D executive to offer the reader some insight into the point of view of R&D executives. The sample is an extract from an interview with RDE1-P, a well known Chief Scientific Officer in the life science industry, who combines his job as university Professor with that of CSO and who has accumulated rich experience in the management of R&D in life science firms....

> *INTERVIEWER*
> *Thank you for this interview... let me start with the first question.. what are the attributes of a chief executive officer in a company like (name of the company)?*
>
> *CSO*
> *I believe that the CEO has to provide confidence and trust in the CSO which has been hired to not only lead a (name of department) in (name of company) but initially confronted with history, where history might be different from the viewpoint the novel CSO brings on board, so what you need to have once you join a company as a CSO is the belief that the CEO, if it would turn out that vision might be different than what is existing in the organisation, that he or she (the CEO) will listen to that novel view. Second if realising that in this case the CEO has more a commercial background and is not fully vested in (name of discipline),*

I think as well it is the task of the CSO to explain as clearly as possible why the given vision will be followed; so it is not so that the CSO has to expect that the CEO has a full understanding and a full scope and idea what it takes to become innovative in (name of department), it's the task of the CSO I believe, to defend his case towards the CEO and the hope is that the perception and the belief and the trust in the CEO is there to come to reasonable collaborative teamwork and agreements. It's a question of confidence and I will try to explain that. When I came here and we rebuilt the plan for the (name of therapeutic area-) team, a number of ideas we had were different from how the CEO but even the chairman of the company looked to it and I do recall we had the presentation meeting towards the second half of January that both said well, 'woow' it is an interesting vision, it's a clear vision but we would like not only to hear this kind of vision from you but it might be nice that we do organise in the company workshop in which we invite some external speakers who are not briefed but which are there to help us - management, shareholders/CEO - to have a second opinion, a second viewpoint and on one hand you might say well that's a weird kind of control but I enormously appreciated that because that convinced me that even while there might have been a gap between how it was in the past and how it should be in the future that it was a big willingness from people who are a bit further away from the daily operations and they wanted to see how that could be translated into reality by hearing the vision from a number of external key opinion leaders - so what we have done since that day ... we have worked out a complete workshop with ten speakers in which we invited top, top notch speakers who basically came here and whom we gave freedom to give their talk and basically what I then did, is try to summarise what we heard, we asked to all speakers the single thing they would recommend to (name of company) and then a week and a half later I took one step back and I invited to my entire department to collect all the things they would have heard which may have been different from what I have heard, but just to make sure that we have captured it all... we used a big wall with 'post-its' which three topics: strategy, technology, biology and basically collected all the things which we had heard and at the very end that was exactly the same vision as what I have presented in January... so I was very happy with that view.....

INTERVIEWER
And you didn't consider that as distrust from his part?

CSO
No, I find it my task to explain why we do something ... in this company basically (name of CEO) had only one single task: get that single drug approved, so it sounds impolite (but that's not the case), this was the furthest away from his concerns what happened in my (name of

department) because that's 'for the future' ... however now that we're getting pretty close to getting feedback from the (name of health authority) and launch, what you will see is ... not only within the company but also in the community - and you start to feel that now already - people always have looked at (name of company) as that company that helps develop that type of (name of drug) but now so many people start to ask what is next?.... so the people start to ask what is in the pipeline...

INTERVIEWER
How do you perceive the CEO's leadership characteristics, which kind of leadership characteristics do you perceive from the CEO?

CSO
Well he gives on the one hand the flexibility ... he has a quite strong controllability but a number of things like how should seating be organised, how should the structure of the pipeline look like, he's pretty much involved not about the science but how a department should look like and how interaction between different departments should be or how interaction between different levels of people should be, just something in which he is quite involved .... what we haven't got and I think it gives you a good idea of how things have moved the last few months ... so till the end of July the focus was 'I want that drug approved' ... so the company here has a management team with the nine department heads coming together every two weeks for an hour and a half to two hours .... basically it turned out that until the end of last month or September even, that these biweekly meetings we covered every single topic except topics from the people in the (name of discipline) have, very often they were removed from the agenda, of course lesser priority ... but (name of CEO) nicely tackled that and understood that this was inefficient and we have now since just two weeks... that we do not have a company wide management team really, we have a meeting 'en petit comité' with the CSO and the two people you're going to see this afternoon... so the four of us basically now have a biweekly hour and a half get together with the CEO and this for the first time – and there was a big need for that - we have an opportunity to fill him in with three things - I'll get back to that in a second - and he has a closer look on what really happens in the department, the last nine months for obvious reasons is being tackled by the installation of an excellent forum, small teams, five people, for preclinical and the CSO to really make sure that the gap is closed.

INTERVIEWER
That gap is that a gap between new ideas and his role …

CSO
No the gap between what is this (name of department) doing and the CEO, so now....

INTERVIEWER
Was this his idea or was it … did you come up and say that we need to talk?

CSO
Yes we often asked, can we talk? ... we both felt that some topics fell off the radar and vice versa, in fact ... we had not a forum to tackle a few things in parallel but because he started to be asked by people what is in the pipeline, what is next ... instead of coming to us on an ad hoc basis, now we have a forum ... the company understands that on one hand (name of discipline) research takes time, takes longer than you always think and will not be sufficient to fill the gap in the pipeline so for that reason we have a new team which basically looks at opportunities which are further developed in the pipeline which we can eventually in-license and move quickly into the clinic, so basically what we cover in our bi-weekly talk is status of scouting, status of predevelopment and organisation.

5.2.2 Final R&D interviews

The operational interview data (interviewee code, recording nr, duration of interview, conversation type, transcript length etc.). are presented in Appendix N. Appendix O collects the quotes extracted from the interview transcripts of the R&D executives and the arguments used to assign these quotes to specific themes, either the literature-based a priori themes (ATI, ATT, COM, INV and INN), the themes developed by CEOs (CEO-OTH) and to new themes developed by the R&D executives (RD-OTH). Interview observations are presented in Appendix P.

5.2.2.1 Content analysis

A total of 34 themes previously used by CEOs are shared with the R&D executives (see Table 5-1) and 29 new themes are identified as themes exclusively used by RD executives (see below Table 5-4). The findings are discussed in the following order:

i. Themes that are shared by both CEOs and R&D executives (see below: *Themes shared by R&D executives and CEOs*). They are divided in frequent a priori themes and less frequent a priori themes and in frequent CEO themes[12] and less frequent CEO themes. Frequent themes appear in more than 50% of the interviews, while less frequent themes appear in less than 50% of the interviews.
ii. Themes which are used by R&D executives but not used by CEOs (see below: *Themes used by R&D executives but not used by CEOs*) and which are divided in

[12] A priori themes are themes extracted from the literature and CEO themes are themes that were developed by CEOs during the CEO interviews to describe their roles in innovation (see Chapter 4)

frequent themes used by R&D executives but not used by CEOs and less frequent themes used by R&D executives but not used by CEOs

iii. Further theme categorization

iv. Themes that are only used by CEOs (see below: *Themes exclusively used by CEOs and not used by RD executives*)

Themes shared by R&D executives and CEOs

The themes shared by R&D executives and CEOs can be divided in literature based a priori themes (ATI, ATT, COM, INV and INN) and themes developed by CEOs (CEO-OTH). They are presented in Table 5-1. In this table the following parameters are used:

Nt: the number of times the theme or subtheme appears in all interviews

Ni: the number of interviews in which the theme appears

Ri: the ratio of the number of interviews in which the theme appears to the total number of interviews. It represents the fraction of interviews in which the theme emerged. The closer Ri to 1, the more a theme emerged in interviews, with Ri = 1 if the theme appears in all interviews and $R_i = 0$ if the theme did not appear in an interview or appeared only marginally (i.e. if in 1 of the 33 interviews or 1/33 = 0.033 or rounded off as 0.0).

The table shows that the majority of the subthemes shared by CEOs and R&D executives are 'other' themes (CEO-OTH3, 4 etc...), i.e. 18 of the 34 themes that emerged from the interviews or 53%. In addition, 4 subthemes are related to attitude (12%), 2 to attention (6%), 3 to commitment (9%), 7 to involvement (21%) and none to innovativeness. The table also presents for each theme the frequency by which it emerges in an interview with a R&D executive (RDE7 to RDE33). For example, the theme 'CEO fosters a culture of innovation' (ATI1) was raised two times (see bold '2'' in the table) by R&D executive RDE9.

In order to structure the findings, it was decided to separate themes that appeared in more than 50% of the interviews (i.e. Ri> 0.5) from the themes that appeared in less than 50% of the interviews ($Ri \leq 0.5$). This threshold was established arbitrarily to structure the observations as there was no rational argument to choose another separation (e.g. 30 vs 70%). The themes that appeared in more than 50% of the interviews are termed 'frequent themes' while the other themes are termed 'less frequent themes'. It should be emphasized however that the separation between frequent and less frequent themes does not imply that less frequent themes are less important than more frequent themes but only that the interviewee attaches more value to the theme in the given context. In other words, a less frequent theme may be important because it may shed light on the appearance of a more frequent theme: it may take the *single* observation of a *single* R&D executive to explain the appearance of strongly emerging themes. The same theme mentioned frequently by different inter-

Number of times a concept (left column) shared by CEOs and R&D executives is used by R&D executives RDE7 to RDE39

Cross-case→ Within case ↓	RDE7	RDE8	RDE9	RDE10	RDE11	RDE12	RDE13	RDE14	RDE15	RDE16	RDE17	RDE18	RDE19	RDE20	RDE21	RDE22	RDE23	RDE24	RDE25	RDE26	RDE27	RDE28	RDE29	RDE30	RDE31	RDE32	RDE33	RDE34	RDE35	RDE36	RDE37	RDE38	RDE39	Nt	Ni	Ri
ATI ATTITUDE																																		**67**		
ATI1			**2**		1	5	1	1		2	1				1	1	5	2	1	3	2			2	1			1		1	1	1		**35**	**20**	**0.6**
ATI3														1	1			1					1	1	1	1					2		2	**11**	**9**	**0.3**
ATI5						1				1	2	1	2		2	1	1	1	3			1	1							1	1			**19**	**14**	**0.4**
ATI7																				1					1									**2**	**2**	**0.1**
ATT ATTENTION																																		**55**		
ATT1		1		1	1	1	2	2	2	3	2	3	2	3	1	1	3	2		1	1	1	2	2			1		1			1		**40**	**24**	**0.7**
ATT2		1		1		3	1	2			1	1												2				1		2				**15**	**10**	**0.3**
COM COMMITMENT																																		**22**		
COM1																	1													1		1		**3**	**3**	**0.1**
COM4			1			1		1				1	1	2			2		1					2				1	1	1				**15**	**12**	**0.4**
COM6				1		2																	1											**4**	**3**	**0.1**
INV INVOLVEMENT																																		**25**		
INV1											1	1						1					2				1							**6**	**5**	**0.1**
INV2						1				1							1	1	1		1						1							**7**	**7**	**0.2**
INV3															1														1					**2**	**2**	**0.1**
INV5																		1																**1**	**1**	**0.0**
INV6	1																			3														**4**	**2**	**0.1**
INV8						2						1																			1			**4**	**3**	**0.1**
INV9								1																										**1**	**1**	**0.0**
CEO-OTH: OTHER ROLES DESCRIBED BY CEOs																																				
CEO-OTH3																		1	1											1	1			**4**	**4**	**0.1**
CEO-OTH4		1																																**1**	**1**	**0.0**
CEO-OTH5			1		1					1	1																							**4**	**4**	**0.1**
CEO-OTH6		1	2		2	2	1	2	3	2	1	2		1	2	1	1	1			3	4			1	2	2	1		1		2	2	**41**	**24**	**0.7**
CEO-OTH7																		1																**1**	**1**	**0.0**
CEO-OTH9										1																								**1**	**1**	**0.0**
CEO-OTH10			1				1									1						1						1			2			**7**	**6**	**0.2**
CEO-OTH12						1				1										1												1		**4**	**4**	**0.1**
CEO-OTH17														1									2											**3**	**2**	**0.1**
CEO-OTH20			1			2	2		1												1		1								1		**9**	**7**	**0.2**
CEO-OTH22																																1		**1**	**1**	**0.0**
CEO-OTH25																		1					1											**2**	**2**	**0.1**

CEO-OTH31	3		2		2	1		4	1	3	1	2	5	1	3	1		9	5	5	3			1	1		3	8	2	2			1	**69**	**24**	**0.7**
CEO-OTH34													1	1																				**2**	**2**	**0.1**
CEO-OTH38		1					1					1				1		1										1		1		1		**8**	**8**	**0.2**
CEO-OTH39	1					1									1		2																	**5**	**4**	**0.1**
CEO-OTH41							1					1		1													1								**4**	**4**	**0.1**
CEO-OTH50														1																				**1**	**1**	**0.0**

Legend: ATI1: CEO fosters a culture of innovation; ATI3: CEO fosters internal communication; ATI5: CEO fosters external collaboration to increase internal innovation; ATI7: CEO fosters learning in the organization; ATT1: CEO sets the direction/goal and vision in which innovation to take place; ATT2: CEO sets the focus and boundaries in which innovation to take place; COM1: CEO hires selects and develops innovative leadership; COM4: CEO makes available human and financial resources; COM6: CEO creates hierarchical flat organizational structures for innovation; INV1: CEO challenges R&D for efficiency; INV2: CEO challenges R&D technically; INV3: CEO acts as sounding board; INV5: CEO is involved in NPD; INV6: CEO holds frequent formalized meetings with R&D; INV8: CEO comes up with new innovative ideas; INV9: CEO evaluates economic viability of R&D project; CEO-OTH3: CEO interacts with R&D only in those matters he/she has personal knowledge in; CEO-OTH4: CEO should not focus on technology; CEO-OTH5: CEO stresses the importance of strong knowledge in the field of innovation; CEO-OTH6: CEO requires R&D data to be simplified for strategic decision and communication; CEO-OTH7: CEO wants R&D to step out of academic thinking; CEO-OTH9: CEO aims to obtain respect from R&D; CEO-OTH10: CEO attempts to understand R&D expertise; CEO-OTH12: CEO considers it an advantage to be untrained in science; CEO-OTH17: CEO acts as a role model for innovation; CEO-OTH20: CEO gets information from/discusses R&D with all levels; CEO-OTH22: CEO looks for the best possible management team; CEO-OTH25: CEO and CSO are innovative forces together; CEO-OTH31: CEO and R&D should have relationship of trust and confidence; CEO-OTH34: CEO needs to understands process/risks of R&D; CEO-OTH38: CEO should have some basic understanding of science; CEO-OTH39: CEOs of LFRD firms should not be dominant; CEO-OTH41: CEO top scientist/top business man/women is ideal; CEO-OTH50: CEO has (no) time to talk to the scientists in R&D; N_t: Number of times the theme or subtheme appears during the interviews; N_i: the number of interviews in which the theme appears; Ri: the ratio of Ni/Ntotal with Ntotal: the total number of interviews.

Table 5-1 Themes shared by CEOs and R&D executives

viewees however shows the importance attached to the theme under the given context (Krippendorff, 2013). This section starts with the findings of the frequent a priori themes shared by R&D executives and CEOs and the less frequent a priori themes shared by R&D executives and CEOs, and continues with the findings of the frequent CEO-OTH themes shared by R&D executives and CEOs and continues with a discussion on the less frequent CEO-OTH themes shared by the R&D executives and CEOs.

Frequent a priori themes shared by R&D executives and CEOs. The frequent a priori themes emerging from the R&D interviews are linked to CEO-attitude and attention. For example, the attitude-related themes ATI1 ('CEO fosters a culture of innovation', Ri 0.6; Nt 35; Ni 20) clearly emerges from the interviews. In addition, both CEOs and R&D executives find that it is important to have a clear direction and vision in which the innovation should take place (ATT1 'CEO sets the direction/goal and vision in which innovation to take place', Ri 0.7; Nt 40; Ni 24). Both attitude and attention related themes were raised frequently by R&D executives (67 and 55 times during the total length of all interviews of 1100 minutes): they are perceived as major CEO roles in innovation.

Less frequent a priori themes shared by R&D executives and CEOs. No theme, indicating the innovativeness of the CEO emerges from the interviews. R&D executives perceive their CEO's innovativeness as a marginal – even obsolete - phenomenon. There is also no other theme (frequent or less frequent) that refers to the innovative character of the CEO – or to the need to have an innovative CEO at the helm of the firm. Less frequent a priori themes observed during the R&D interviews are, in decreasing order:

- ATI5 ('CEO fosters external collaboration to increase internal innovation'; Ri 0.4)
- COM4 'CEO makes available human and financial resources'; Ri 0.4)
- ATI3 ('CEO fosters internal communication'; Ri 0.3)
- ATT2 ('CEO sets the focus and boundaries in which innovation to take place'; Ri 0.3)
- INV2 ('CEO challenges R&D technically'; Ri 0.2)
- ATI7 ('CEO fosters learning in the organization'; Ri 0.1)
- COM1 ('CEO hires selects and develops innovative leadership'; Ri 0.1)
- COM6 ('CEO creates hierarchical flat organizational structures for innovation'; Ri 0.1)
- INV1 ('CEO challenges R&D for efficiency'; Ri 0.1)
- INV3 ('CEO acts as a sounding board'; Ri 0.1)
- INV5 ('CEO is involved in NPD'; Ri 0.1)
- INV6 ('CEO holds frequent formalized meetings with R&D'; Ri 0.1)
- INV8 ('CEO comes up with new innovative ideas'; Ri 0.1 and
- INV9 ('CEO evaluates economic viability of R&D project'; Ri 0.0)

It is not surprising that commitment (COM1, 4 and 6) is shared by both CEOs and R&D executives as CEO commitment is crucial seen the cash burn in these companies.

Frequent CEO themes shared by R&D executives and CEOs. Besides the a priori literature themes, Table 5-1 also collects CEO themes which are used by R&D executives to describe the roles of their CEOs. The themes

- CEO-OTH31 ('CEO and R&D should have relationship of trust and confidence' Ri 0.7) and
- CEO-OTH6 ('CEO requires R&D data to be simplified for strategic decision and communication' Ri 0.7)

are themes shared by CEOs and R&D executives and which are clearly emphasized. The theme addressing the relationship between CEO and R&D based on trust (CEO-OTH31) is mentioned 69 times during the interviews while the theme that refers to the complexity reduction of R&D knowledge (CEO-OTH6) is mentioned 41 times, indicating that both themes are in the top of the R&D executives' mind when referring to the role of the CEO in innovation. This is illustrated in Figure 5-1.

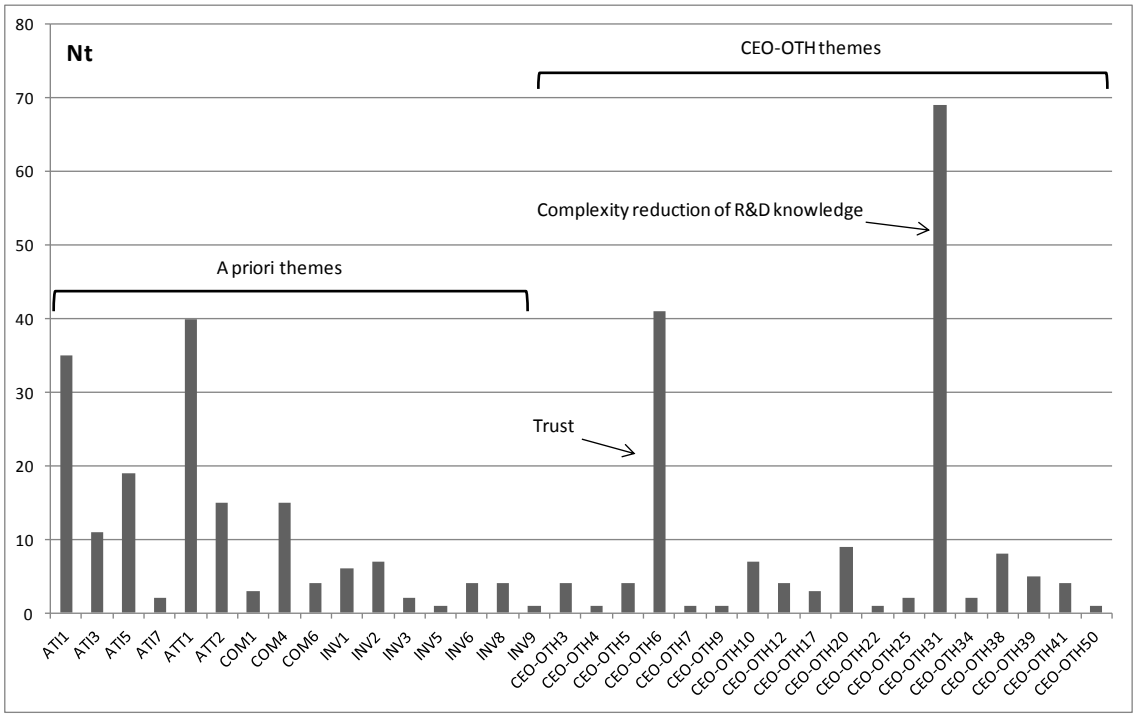

Figure 5-1 Emergence of trust and complexity reduction during R&D interviews

During the interviews, the importance of the theme of trust (CEO-OTH31) was clearly articulated by the R&D executives[13] as is illustrated by RDE7**,** the CSO of a small biotech firm and a world renown scientist (see also Appendix P). He/she has made his/her name in industry and in academia in a particular area of biomedical science. However, his/her experience in dealing with CEOs has not been without problems. The fact that one of the drugs that were under development did not make it to the market, was - according

[13] Note: although trust is a shared theme between CEOs and R&D executives, CEOs referred to trust in a strikingly lower emphasis. This is discussed in detail in Chapter 6.

to this CSO - caused by the fundamental problem of the difference in view between CSO and CEO. The CEO was a dominant- science educated - individual who managed with 'rigidity and control' and made decisions on his/her own without paying attention to the concerns and scientific/medical arguments of the CSO and his/her team. The CSO therefore is convinced that an effective CEO in a life science R&D firm.

> *'would only work if the CEO had senior scientists who had a very good relationship with them and there was a bond of trust'*

The table below (Table 5-2) collects a number of quotes made by the R&D executives on the concept of trust. They are extracted from the interview observations in Appendix P.

R&D	Quote on trust
RDE12	*'...I think certainly trust and belief (by the CEO) in the team is very important'*
RDE14	*'...'trust (from the CEO) is always important'*
RDE15	*..so I do fully understand the need for a different type of CEO that is more commercially oriented which has less R&D or life science experience but should trust us'*
RDE16	*'...capturing the complexity so that you (RED16 refers to the CEO) know when you (the CEO) can take the right decision also from your (the CEO) own experience and not only because your people tell it- I mean you have to trust your people no problem...'*
RDE33	*'...'I think trust and challenge for me on the CEO level is absolutely essential because you can deconstruct any R&D organization if you ask the nasty questions, you just don't always have answers and that's where the trust part comes in'*

Table 5-2 A number of quotes from R&D executives on trust

R&D executives also shared the need for complexity reduction of their knowledge with the CEOs (CEO-OTH6) and hence recognize the theme of absorptive capacity that was identified in Chapter 4. According to RDE33, a senior vice president of a big pharma company:

> *'....we titrated ourselves or each other really to a middle ground where we can talk about value and risk...'*

Another R&D executive, RDE8, is a senior scientist hired by a CEO-accountant (CEO2-P). RDE8 only focuses on the essentials of the R&D message to avoid the CEO to be drawn into the details of science and prepares a R&D message that is reduced in complexity. He/she compares the transformation of a complex R&D message as 'a key art'..:

> *'I don't regard simplification as sort of a patronising thing, to simplify the science is not something you do to patronise people who don't understand science, ... to simplify science and its objectives is a key commercial art anyway because you know what's key at the end of it is still down to the objectives, the value, the time it takes to get there'*

The table (Table 5-3) below collects a number of quotes made by the R&D executives on the concept of complexity reduction. They are extracted from the interview observations in Appendix P.

R&D	Quote on complexity reduction
RDE20	'*I simplify the message for him to understand and not necessarily because he doesn't understand, I think in particular in my area he's quite confident but just because I see him once a month and if I bother him with the latest analytical problem he will get confused'*
RDE23	*'... I would try to adapt to the person and depending if it would be a financial guy you would use more financial data at the end of the day you would say look that we could make a business plan. '*
RDE27	*…'the language (used in the communication of R&D knowledge between the R&D function and the CEO) has to match that of the understanding of the CEO'*
RDE12	*'it's more a responsibility that you have to tell your story to the management team you have to make sure that they understand this, ... you have to translate the project and this takes a lot of my time because it's not my core activity... it's a responsibility that I should not forget doing '*
RDE14	*'... you need to reduce it in its complexity in order for them to grasp it quickly, it helps a lot because it focuses also the thinking about your own issues ... I don't see this as an issue, I have to be able to explain this to my wife for example'*

Table 5-3 A number of quotes from R&D executives on complexity reduction

Less frequent CEO themes shared by R&D executives and CEOs. R&D executives also observe that CEOs are mainly interested in those aspects of R&D activities in which they can contribute because of personal expertise (CEO-OTH3 'CEO interacts with R&D only in those matters he/she has personal knowledge in'; Ri 0.1). In addition, some R&D executives argue not to focus on technology (CEO-OTH4; Ri 0.1) and want R&D to step out of academic thinking (CEO-OTH7; Ri 0.0). According to some R&D executives (RDE9, RDE11, RDE16 and RDE17) it is important that a CEO should have strong knowledge in the field of innovation (CEO-OTH5 'CEO stresses the importance of strong knowledge in the field of innovation'; Ri 0.1). However, other R&D executives find it useful to have CEOs at the helm of the company who are untrained in science (CEO-OTH12 'CEO considers it an advantage to be untrained in science'; Ri 0.1). Other shared less frequent themes have a more general character such as CEO-OTH9 ('CEO aims to obtain respect from R&D'). The theme CEO-OTH41 ('CEO top scientist/top business man/women is ideal'; Ri 0.1) shows that some R&D executives consider CEOs who thoroughly understand the science, have extraordinary business acumen and are capable 'to make money' using this R&D knowledge, are the 'ideal' CEOs for life science R&D firms. Still other less frequent themes are in decreasing order:

- CEO-OTH10 ('CEO attempts to understand R&D expertise'; Ri 0.2),
- CEO-OTH20 ('CEO gets information from/discusses R&D with all levels'; Ri 0.2),
- CEO-OTH38 ('CEO should have some basic understanding of science'; Ri 0.2)
- CEO-OTH17 ('CEO acts as a role model for innovation'; Ri 0.1),
- CEO-OTH25 ('CEO and CSO are innovative forces together'; Ri 0.1),
- CEO-OTH34 ('CEO needs to understand process/risks of R&D; Ri 0.1)
- CEO-OTH39 ('CEOs of LSRD firms should not be dominant; Ri 0.1)

- CEO-OTH22 ('CEO looks for the best possible management team'; Ri 0.0),
- CEO-OTH50 ('CEO has (no) time to talk to the scientists in R&D'; Ri 0.0)

Finally, when asked about the ideal CEO for a life science R&D firm, R&D executives argue that these CEOs should not act as dominant figures (CEO-OTH39; Ri 0.1).

Themes used by R&D executives but not used by CEOs

R&D executives also use themes to describe the roles of CEOs in innovation that are not used by CEOs. These themes are presented in Table 5-4 below. It presents the themes (first column) and indicates their frequency in each individual interview and during all interviews. The table includes the same parameters Nt, Ni and Ri as in previous tables. The data are also are graphically presented in Figure 5-2 below.

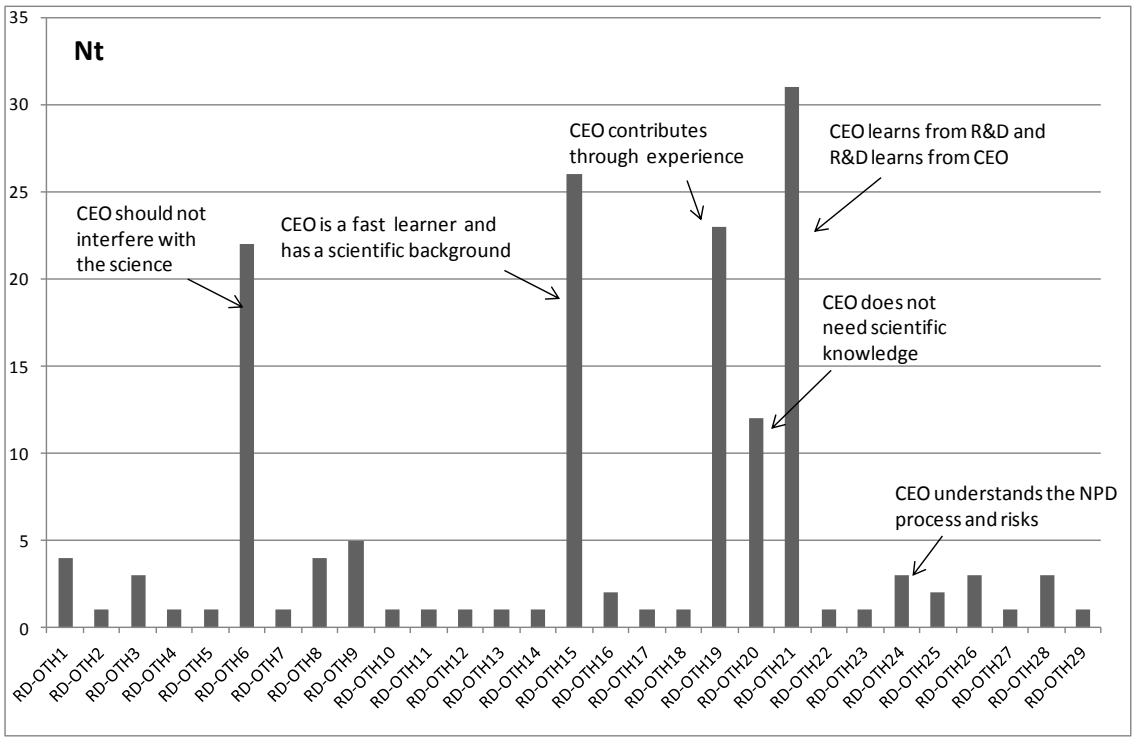

Figure 5-2 The themes exclusively used by R&D executives and their emergence

Frequent themes used by R&D executives but not used by CEOs. The theme RD-OTH21 ('CEO learns from R&D and R&D learns from CEO' Ri 0.5) is a frequently recurring theme and is the most frequently used theme by R&D executives. When they argue that they teach CEOs about their science, they expect from their CEOs to teach them about management, the market and about the place of their research in the overall strategy of the firm. R&D executives want to learn from their CEOs in order for them to make sense of their research activities and – therefore – to become involved in the

Number of times a theme used exclusively by R&D executives emerges from R&D interviews																																								
Cross-case→ Within case ↓	**RDE7**	**RDE8**	**RDE9**	**RDE10**	**RDE11**	**RDE12**	**RDE13**	**RDE14**	**RDE15**	**RDE16**	**RDE17**	**RDE18**	**RDE19**	**RDE20**	**RDE21**	**RDE22**	**RDE23**	**RDE24**	**RDE25**	**RDE26**	**RDE27**	**RDE28**	**RDE29**	**RDE30**	**RDE31**	**RDE32**	**RDE33**	**RDE34**	**RDE35**	**RDE36**	**RDE37**	**RDE38**	**RDE39**	**Nt**	**Ni**	**Ri**
RD-OTH1	2											1												1										**4**	**3**	**0.1**
RD-OTH2	1																																	**1**	**1**	**0.0**
RD-OTH3	2																								1									**3**	**2**	**0.1**
RD-OTH4	1																																	**1**	**1**	**0.0**
RD-OTH5	1																																	**1**	**1**	**0.0**
RD-OTH6	2									3	6		1	1			1			1	1		1				1					2	2	**22**	**12**	**0.3**
RD-OTH7		1																																**1**	**1**	**0.0**
RD-OTH8		4																																**4**	**1**	**0.0**
RD-OTH9		1					1		2						1																			**5**	**4**	**0.1**
RD-OTH10		1																																**1**	**1**	**0.0**
RD-OTH11		1																																**1**	**1**	**0.0**
RD-OTH12		1																																**1**	**1**	**0.0**
RD-OTH13		1																																**1**	**1**	**0.0**
RD-OTH14			1																															**1**	**1**	**0.0**
RD-OTH15			1		2						4		2		5		1				1	2	2	1						1	3		1	**26**	**13**	**0.4**
RD-OTH16				1																											1			**2**	**2**	**0.1**
RD-OTH17				1																														**1**	**1**	**0.0**
RD-OTH18					1																													**1**	**1**	**0.0**
RD-OTH19						3	1				4		1					1			2	3	1	1	1	1					1	3		**23**	**13**	**0.4**
RD-OTH20						1	1	1		1	1		1					2	1		1					1						1		**12**	**11**	**0.3**
RD-OTH21						3	4		4	1		1	1		1			1	2	2				1			4	1		2	3			**31**	**15**	**0.5**
RD-OTH22							1																											**1**	**1**	**0.0**
RD-OTH23									1																									**1**	**1**	**0.0**
RD-OTH24										1	1															1								**3**	**3**	**0.1**
RD-OTH25										1	1																							**2**	**2**	**0.1**
RD-OTH26														2	1																			**3**	**2**	**0.1**
RD-OTH27														1																				**1**	**1**	**0.0**
RD-OTH28														1								1	1											**3**	**3**	**0.1**
RD-OTH29																								1										**1**	**1**	**0.0**

Legend: Nt: Number of times the concept or subthemes appears in the interviews; Ni: the number of interviews in which the theme appears; Ri: the ratio of Ni/Ntotal with Ntotal: the total number of interviews; RD-OTH1: CEO should focus on common good and act beyond personal ambition; RD-OTH2: CEO manages LSRD firms with rigidity and strict control; RD-OTH3: CEO manages qualitatively and quantitatively**;** RD-OTH4: CEO should be forceful and full of drive;RD-OTH5: CEO has a strong cultural and literature background; RD-OTH6:

CEO should not interfere with the science; RD-OTH7: CEO should balance industrial vs. academic work; RD-OTH8: CEO requires a balanced view of the potential of R&D; RD-OTH9: CEO should be capable to evaluate R&D knowledge; RD-OTH10: CEO should be located in proximity of the R&D site; RD-OTH11: CEO makes final R&D decision; RD-OTH12: CEO is a good listener;RD-OTH13: CEO is capable to talk the language of scientists; RD-OTH14: CEO should *lead* scientists, not *manage* them; RD-OTH15: CEO is a fast learner and has a scientific background; RD-OTH16: CEO should involve all levels of R&D; RD-OTH17: CEO is not expected to come up with new ideas; RD-OTH18: CEO should drive R&D not only from a financial point of view; RD-OTH19: CEO contributes to R&D by means of his/her experience; RD-OTH20: CEO does not need scientific knowledge (but when it is available it may help); RD-OTH21: CEO learns from R&D and R&D learns from CEO; RD-OTH22: CEO balances short-term vs. long term innovation; RD-OTH23: CEO is a good communicator;RD-OTH24: CEO understand the new product development process and its risks; RD-OTH25: CEO should be willing to take risks in innovation; RD-OTH26: CEO makes sure that innovation is conducted in compliance with regulations; RD-OTH27: CEOs should be brought back to scientific reality; RD-OTH28: CEOs should embrace new innovative ideas; RD-OTH29: CEO should make time available for R&D. N_t: Number of times the theme or subtheme appears during the interviews; N_i: the number of interviews in which the theme appears; R_i: the ratio of N_i/N_{total} with N_{total}: the total number of interviews.

Table 5-4 Themes used by R&D executives but not by CEOs

building of an overall strategy of the firm. Transforming R&D data for transfer to the CEO learns the R&D function to think about the business context of their activities thereby linking the concept of absorptive capacity with the concept of learning. According to RDE33:

> *'the data from R&D are being transformed, or modified such that it becomes open to challenge, the challenge is to simplify data, actually learn R&D, it is the coaching of R&D to become a business organization, it's for me a vital part of what's happening'*

In other words, it is not only the CEO who learns from R&D by means of the de-complexified knowledge, also R&D executives learn about the CEO's knowledge by doing so. This is clearly exemplified by RDE33:

> *'the simplification process is also a very valuable process for both parties to learn from each other'*

It is not surprising that R&D executives emphasize the concept of learning. As they the key knowledge workers in the firm, learning constitutes an essential element of their professional responsibility.

Less frequent themes used by R&D executives but not used by CEOs. Less frequent themes emerging from the R&D executives are for example:

- RD-OTH15 ('CEO is a fast learner and has a scientific background'; Ri 0.4),
- RD-OTH19 ('CEO contributes to R&D by means of his/her experience'; Ri 0.4),
- RD-OTH6 ('CEO should not interfere with the science'; Ri 0.3),
- RD-OTH20 ('CEO does not need scientific knowledge'; Ri 0.3)

Other less frequent themes are linked to the availability of the CEO to interact with all levels of the R&D organization (RD-OTH16 'CEO should involve all levels of R&D'; Ri 0.1) which is the mirror R&D theme used by the CEOs (CEO-OTH20 'CEO should interact with all levels of the firm'). From a viewpoint of innovative ideation, R&D executives expect their CEOs to be open for new innovative ideas (RD-OTH28 'CEOs should embrace new innovative ideas'; Ri 0.1) and dare to take risks (RD-OTH25 'CEO should be willing to take risks in innovation'; Ri 0.1). The CEO, according to some R&D executives, should be capable to evaluate new knowledge (RD-OTH9 'CEO should be capable to evaluate R&D knowledge'; Ri 0.1 and RD-OTH8 'CEO requires a balanced view of the potential of R&D'; Ri 0.0) and should not 'manage' scientists (RD-OTH14; Ri 0.0). R&D executives refer to their CEOs as fast learners having a scientific background (RD-OTH15; Ri 0.4) or as individuals with lack of knowledge in the area of R&D (RD-OTH20; Ri 0.3) or having acquired knowledge through experience such that they contribute to R&D (RD-OTH19; Ri 0.4).

Further theme categorization

The discussion above analyses the data as they emerged from the interviews, i.e; without further sub-categorization and as granular themes. However, the data lend themselves to further categorization. For example two themes emerged from the R&D interviews that address two concepts that are sensitive to R&D scientists in that the role of the CEO should exclude him/her meddling with the science (RD-OTH6) and that the CEO should not 'manage' science (RD-OTH14). They are brought together under the theme 'CEO and science' (see Table 5-6).

In addition, R&D executives frequently address the concept of knowledge as indicated in Table 5-6 (RD-OTH9, 15, 19, 20, 21 and 24). The themes on knowledge used exclusively by R&D executives are brought together under the theme 'CEO knowledge'. The table shows that knowledge related themes are strongly emphasized by the R&D executives (Nt 100 for all subthemes combined). Both the themes addressing knowledge used exclusively by R&D executives and those shared with CEOs are summarized and compared in Table 5-5 below.

Themes on knowledge shared by CEOs and R&D executives (see Table 5-1):
CEO-OTH3: CEO interacts with R&D only in those matters he/she has personal knowledge in
CEO-OTH5: CEO stresses the importance of strong knowledge in the field of innovation
CEO-OTH10: CEO attempts to understand R&D expertise
CEO-OTH12: CEO considers it an advantage to be untrained in science
CEO-OTH34: CEO needs to understands process/risks of R&D
CEO-OTH38: CEO should have some basic understanding of science
Themes on knowledge used exclusively by R&D executives (see Table 5-4):
RD-OTH9: CEO should be capable to evaluate R&D knowledge
RD-OTH15: CEO is a fast learner and has a scientific background
RD-OTH19: CEO contributes to R&D by means of his/her experience
RD-OTH20: CEO does not need scientific knowledge (but when it is available it may help)
RD-OTH21: CEO learns from R&D and R&D learns from CEO
RD-OTH24: CEO understand the new product development process and its risks

Table 5-5 Comparing themes on knowledge shared with CEOs and R&D

During the interviews the need for relevant CEO prior knowledge did not emerge as a uniform theme and it was therefore decided to reanalyze the R&D interview transcripts in an attempt to find structure in the R&D executives' view on (the need for) prior CEO knowledge. For example, R&D executives – on the one hand – argue that CEOs should profit from a scientific background (RD-OTH15), should understand the risks of R&D (CEO-OTH34) and of NPD (CEO-OTH24), should have a basic understanding of science (CEO-OTH38) but – on the other hand – find it advantageous for a CEO to be untrained in science (CEO-OTH12) or not having scientific knowledge (RD-OTH20). Table 5-8 presents the results of this analysis and includes a spectrum of knowledge perceptions of the R&D executives using quotes made by R&D executives that underpin the individual perceptions of knowledge. It could be argued that the

Further theme categorization of themes used exclusively by R&D executives																																						
Cross-case→ Within case ↓	**RDE7**	**RDE8**	**RDE9**	**RDE10**	**RDE11**	**RDE12**	**RDE13**	**RDE14**	**RDE15**	**RDE16**	**RDE17**	**RDE18**	**RDE19**	**RDE20**	**RDE21**	**RDE22**	**RDE23**	**RDE24**	**RDE25**	**RDE26**	**RDE27**	**RDE28**	**RDE29**	**RDE30**	**RDE31**	**RDE32**	**RDE33**	**RDE34**	**RDE35**	**RDE36**	**RDE37**	**RDE38**	**RDE39**	**Nt**	**Ni**	**Ri**
CEO and science																																		**24**	**12**	**0,4**
RD-OTH6	2									3	6		1	1			1			1	1		1				1					2	2	**22**	**12**	**0.3**
RD-OTH14			1																															**1**	**1**	**0.0**
CEO knowledge																																		**100**	**11**	**0,8**
RD-OTH9		1					1		2						1																			**5**	**4**	**0.1**
RD-OTH15			1		2						4		2		5		1				1	2	2	1						1	3		1	**26**	**13**	**0.4**
RD-OTH19						3	1				4		1					1			2	3	1	1	1	1					1	3		**23**	**13**	**0.4**
RD-OTH20						1	1	1		1	1		1					2	1		1					1						1		**12**	**11**	**0.3**
RD-OTH21						3	4		4	1		1	1		1			1	2	2				1			4	1		2	3			**31**	**15**	**0.5**
RD-OTH24										1	1															1								**3**	**3**	**0.1**
CEO limits of science																																		**5**	**2**	**0.1**
RD-OTH8		4																																**4**	**1**	**0.0**
RD-OTH27														1																				**1**	**1**	**0.0**

RD-OTH6: CEO should not interfere with the science; RD-OTH8: CEO requires a balanced view of the potential of R&D; RD-OTH9: CEO should be capable to evaluate R&D knowledge; RD-OTH14: CEO should *lead* scientists, not *manage* them; RD-OTH15: CEO is a fast learner and has a scientific background; RD-OTH19: CEO contributes to R&D by means of his/her experience; RD-OTH20: CEO does not need scientific knowledge (but when it is available it may help); RD-OTH21: CEO learns from R&D and R&D learns from CEO; RD-OTH24: CEO understands the new product development process and its risks; RD-OTH27: CEOs should be brought back to scientific reality; Nt: Number of times the theme or subtheme appears during the interviews; Ni: the number of interviews in which the theme appears; Ri: the ratio of Ni/Ntotal with Ntotal: the total number of interviews

Table 5-6 Further theme categorizations from R&D interviews

variation in opinion among the R&D executives of the need for CEO prior knowledge is caused by the prior knowledge of the CEOs. In other words, R&D executives who report to a CEO with limited knowledge in the field of R&D would report a higher need for expert knowledge than R&D executives who report to CEOs who have expert knowledge in the field. However, a relationship between CEO education and R&D's need for CEO prior knowledge cannot be found. For example, the chief scientific officer who reports to a CEO-investment banker does not consider it necessary for the CEO to have scientific knowledge. R&D executives who report to scientifically knowledgeable CEOs argue that there is no need for that level of knowledge at that level in the company, because science develops so fast that it is impossible for him/her to keep track of developments anyway. Accordingly, R&D executives who report to CEOs with limited or no scientific background do not necessarily perceive this as a disadvantage. In other words, the CEO's knowledge requirements as seen from the R&D executives perspective do not overlap with the CEO's educational /experience background. This is illustrated in the table below (Table 5-7). It lists the R&D executives who argue that there is no need for a CEO to have scientific prior knowledge. As is shown, these R&D executives report to CEOs who have no scientific background (MBA, economics, law) as well as to CEOs with a strong science background (MD, MD/PhD, PhD). R&D executives RDE27 and RDE28 who report to scientifically well trained CEOs such as CEO9, do not consider this to be advantageous and R&D executives such as RDE12, RDE13 and RDE19 who report to CEOs with no background knowledge such as CEO3 do not find this to be disadvantageous.

Since the arguments and statements made by the R&D executives and CEOs on the concept of knowledge are inconsistent it was decided not to explore the concept of knowledge in the context of life science R&D any further as the exploratory approach and the interview questions did not allow further elucidation of the concept. Further research of this theme will require a separate systematic review of the literature, and should take into account the multidimensionality of the concept, the different gradations (no knowledge, basic knowledge, expertise knowledge) and the factors that constitute the basis (education, experience, R&D specific, business knowledge etc). In other words, it requires another and more focused approach that goes beyond the objective of this research.

R&D executives who argue that there is no need for a science background of the CEO	**CEO to whom the R&D executives report**	**Background of the CEO**
RDE12, RDE13, RDE14	CEO3	Economics
RDE17, RDE19	CEO5	PhD science/law degree
RDE24, RDE25	CEO8	Engineering/ consultant
RDE27, RDE28	CEO9	MD, PhD immunology
RDE30	CEO11 (big pharma)	Law
RDE32	CEO12 (big pharma)	BSc Science, marketing
RDE38	CEO15	PhD biology

Table 5-7 Overview of R&D executives who do not need science CEOs and their CEOs

Quotes made by R&D executives on CEO prior knowledge perceptions					
NO R&D KNOWLEDGE	**NO R&D KNOWLEDGE BUT EAGER TO LEARN**	**BASIC R&D KNOWLEDGE**	**NPD KNOWLEDGE ONLY**	**PRIOR R&D KNOWLEDGE ON THE TOPIC OF RESEARCH**	**EXPERT R&D KNOWLEDGE**
CEO has no knowledge on the science that governs the R&D activities because it is not necessary	The CEO has no or limited science background (but makes efforts to understand the science and that is important for R&D)	The CEO needs basic knowledge on a natural science discipline (but not necessarily related to the science that governs the R&D activities)	The CEO should have knowledge on new product development processes and the risks that they entail	The CEO should have prior knowledge on the R&D that takes place in the company (i.e. when the firm conducts immunological research, he/she can talk 'immunology')	The CEO should have expert knowledge on the science that governs the R&D activities
Comments by R&D executives:	**Comments by R&D executives:**	**Comments by R&D executives:**	**Comments by R&D executives:**	**Comments by R&D executives:**	**Comments by R&D executives:**
'The CEO does not need a scientific background (RDE12) 'The CEO does not to have a science background because, if you cannot convincingly present the opportunity as a scientist then it is probably not a good opportunity' (RDE12) 'It is more important for the CEO to have experience in the field rather than a relevant academic or educational background' (RDE12) 'CEO experience is more important than CEO knowledge' (RDE13) 'It is not a disadvantage to have a non-science CEO because it increases the diversity' (RDE14) 'The CEO does not need prior knowledge on the topic' (RDE25)	'The CEO wants to understand what we are doing' (RDE19) 'The CEO is learning the science and talk s to everybody in order to learn about the science' (RDE13) 'The CEO is very eager to learn' (RDE13) 'The CEO wants to learn because he/she has no knowledge but is interest in R&D' (RDE13) 'The CEO always tries to understand' (RDE24) 'The CEO wants to understand what is going on in R&D' (RDE37)	'The CEO needs some knowledge about the science' (RDE16) 'The CEO doesn't need to know the ins and outs of the detailed science and that's one of the dangers is that when you talk to an academic' (RDE8) 'It would have helped the company if the CEO was scientifically trained' (RDE8) 'A CEO without any knowledge on the science that is conducted and is only knowledgeable about the finance is catastrophic' (RDE11) 'A non-science CEO needs to be controlled in order to prevent him/her to make the wrong conclusions' (RDE17) 'A CEO understands (and should understand) the basics of our R&D' (RDE18)	'The CEO should certainly be familiar with the processes involved in drug development, understand the risk (commercial, technical etc)' (RDE17) 'A CEO understands the process and risks of new product development' (RDE19) 'A CEO is knowledgeable about the new product development process' (RDE20) 'A CEO had the knowledge to steer the development in the company' (RDE26) 'A CEO needs process knowledge (what is achievable? What are the risks?)' (RDE31) 'A CEO needs to understand how R&D is progressing' (RDE37)	'I think it is important the CEO has prior knowledge because he is the one to give us direction; so if he does not understand where we want to go he will not give us a direction ... if he's not convinced he will give us much less or not adequate budget' (RDE9) 'A CEO has a good high-level understanding of the science projects in our firm' (RDE17) 'Prior knowledge of the CEO leads to faster decision making' (RDE19) 'The need of prior knowledge depends on how good R&D operates' (RDE278)	'A CEO with expert knowledge need to take a step back from the science' (RDE17) 'A CEO with expert knowledge and interferes with the science will risk losing all his scientists' (RDE17) 'Good scientists do not make good CEOs' (RDE17) 'A CEO with 'CSO knowledge' cannot be a good CEO' (RDE20) 'A CEO and I could discuss the science problems and the pros and cons of the approach' (RDE27) 'A CEO who understand the science is more capable in securing money' (RDE37)

Table 5-8 Spectrum of CEO science knowledge as perceived by R&D executives

The concept of learning appears frequently during the interview with the R&D executives. They refer to learning as dyadic exchange of knowledge whereby both actors exchange data and learn from each other. In order to obtain a good understanding of what R&D executives mean by 'learning', the R&D transcripts were reanalyzed to look for quotes and arguments that specifically address the concept of 'learning'. Table 5-9 offers an overview of the 'learning' concept as it emerged during the interviews. It is clear that the learning process covers both learning of CEOs by R&D and R&D by CEOs.

LEARNING PROCESSES BETWEEN R&D AND CEO		
CEO to R&D	**R&D to CEO**	**Learning each other**
'...his experience, his previous experience from other companies is definitely also something that we can learn from, that's what I'm doing for the moment so he learns me how to develop starting from an idea to go to a product so I also see that as a learning curve from his experience yes because most of the time it's a start up like we are so we are coming from the academic world and we don't have the idea from how to develop something out into the market so it's a learning curve and he's definitely there and has a leading role' (RDE37) '...and I learnt a lot from the CEO' (RDE37) 'Well its each time a bit different with another CEO, in the case of this CEO it is again learning in a very intense way on how to structure and focus our business and our activities, at the same time he is very friendly, he can laugh, he can party and he thinks he cares about patients' (RDE12) 'We really learn a lot from him ... how our company is placed in the market or its connections to others and partnering in collaboration there we learn a lot of then how these contexts – but scientifically really pure the science that we do and that goes to the scientist' (RDE25) '...look an accountant without any knowledge and - even worse - without any interest who just runs the company like he does .... that's not good I think, that's not good because I do not learn' (RDE13) 'I think the much broader picture and the strategy .... I feel our CEO has much more experience and has completely other ideas about how to manage a team and how to do that in parallel with the science... managing a team is for example one of the things I am learning from our CEO much more then from the CSO and this I think for me at least is very important and welcome' (RDE26)	'There is no knowledge gap between you and the CEO at this stage.... because also for him its important for him to know, to have the knowledge because he needs to explain it to potential partners to a potential investor and he wants to learn it, he wants to understand it' (RDE37) 'You know I studied philosophy before I studied medicine and those are problems, the education of the CEO if he'd learnt to read a novel properly and analyse literature it tells you about human relationships, they'd do a lot better than going to a business school' (RDE7) 'He /she is capable of understanding the science behind it because to some extent he's a fast learner' (RDE11) 'Well we had the case of course with the CEO who had no knowledge and who was a slow learner, of course that didn't work at all, we have now we have a new CEO and he is a science background but he's a fast learner so and he's really well trained' (RDE11) 'I think he's learning a lot, he's reading a lot about what we also exchange all of the information with each other, we go together to scientific meetings. I join him in business meetings and we have several people who do that also from the marketing team, there's quite a lot of interaction between him/her and his team and so he's learning fast, he has already learned a lot about the science' (RDE12) 'Every time we have these type of discussions and need to make decisions he'll be able to understand a little bit more about the science behind these types of messages, so I don't see myself as a teacher for him that's not it but it's something that happens in the process anyway' (RDE15) 'There might be a very small gap but it is minor because I think what we also do, he/she is also doing reading, business development, reach out to pharma	'Learning, definitely, that definitely goes both ways because you can hardly predefine, well unless you go to such a high level of methodologic aggregation and just talk – that's I think the most abstract you can do and it could be all kinds of bullshit behind that, excuse my German and finding a level that is more appropriate I think that's the two-way learning experience' (RDE33) 'I learn from the CEO and the CEO learns me' (RDE12) 'I expect to learn from the CEO and I expect to learn the CEO something that you know' (RDE15)

	companies, he's very active in this, also for finding out if the programs in which we are working if these make sense also for a pharma party ... you have to reach out to pharma parties and having those discussions I'm also involved in this, you learn a lot' (RDE21)	

Table 5-9 Learning processes between R&D and CEO

In addition, R&D executives also refer to the themes of 'understanding the limits of science by the CEO' (RDE-OTH8 and RD-OTH27, respectively 'CEO requires a balanced view of the potential of R&D' and 'CEOs should be brought back to scientific reality'). It became clear during the interviews that R&D executives are concerned by the idea that CEOS 'run away' with the achievements of R&D before these are validated and create a hype with the top management team, the board members and - even worse - the external stakeholders before they were able to find substantial evidence for their findings. These are brought together under the theme 'CEO limits of science' (see Table 5-6).

Themes exclusively used by CEOs and not used by R&D executives

A number of themes are not shared between CEOs and R&D executives and are not used exclusively by R&D executives but are only used by CEOs. Table 5-10 below lists the themes that are used by CEOs to describe their roles and which are not shared by R&D executives. The table lists the themes and the following parameters:

Nt: the number of times the theme or subtheme appears in all interviews
Ni: the number of interviews in which the theme appears
Ri: the ratio of the number of interviews in which the theme appears to the total number of interviews.

The CEO-specific themes focus on attitude (ATI2 'CEO fosters experimentation and accepts failure'), ATI4 ('CEO fosters exchange of diverse ideas'), ATI6 ('CEO fosters flexibility and adaptability') and the fear that too much procedural impact may stifle innovation, ATI8 ('CEO states that processes may stifle innovation'), commitment (COM2 'CEO creates incentives and prioritization), COM3 ('CEO prioritizes resources), INV4 ('CEO interacts with R&D to solve technical questions'), INV7 ('CEO is involved at the beginning followed by delegation'), INV7 ('CEO picks up innovational opportunities'), INN1 ('CEO drives the innovation him/herself') and a myriad of other themes as presented in the table.

Themes exclusively used by CEOs:	**Nt**	**Ni**	**Ri**
ATI2 CEO fosters experimentation and accepts failures	**6**	**6**	**0.4**
ATI4 CEO fosters the exchange of diverse ideas	**10**	**6**	**0.4**
ATI6 CEO fosters flexibility and adaptability	**2**	**2**	**0.4**
ATI8 CEO states that processes may stifle innovation	**5**	**3**	**0.6**
ATI9 CEO has an inquisitive nature: asking, listening, probing	**1**	**1**	**0.1**
COM2 CEO creates incentives and rewards for the R&D function	**8**	**6**	**0.4**

COM3 CEO prioritizes resources	**8**	**4**	**0.3**
INV4 CEO interacts with R&D to solve technical problems	**1**	**0**	**0**
INV7 CEO is involved at the start of an R&D project and then delegates it	**3**	**3**	**0.6**
INV10 CEO picks up to R&D innovational opportunities	**1**	**1**	**0.1**
INN1 CEO drives new product development in person	**1**	**1**	**0.1**
CEO-OTH1 CEO admits limited knowledge in specific R&D area	**2**	**2**	**0.4**
CEO-OTH8 CEO role model is knowledge based	**1**	**1**	**0.1**
CEO-OTH15 CEO role model is business driven	**2**	**2**	**0.4**
CEO-OTH16 CEO wants to protect R&D from the mundane aspects of running a firm	**2**	**2**	**0.4**
CEO-OTH18 CEO role is to link R&D to internal & external stakeholders	**2**	**2**	**0.4**
CEO-OTH19 CEO reduces risk by fail fast fail cheap	**4**	**3**	**0.6**
CEO-OTH21 CEO role in R&D is not different from CEO role in non-R&D	**1**	**1**	**0.1**
CEO-OTH23 CEO requires persistence and resilience in LFSR	**3**	**2**	**0.4**
CEO-OTH24 CEO argues that innovation comes from top down and bottom up	**4**	**3**	**0.6**
CEO-OTH26 CEO innovates by challenging the organization (time, costs etc)	**2**	**2**	**0.4**
CEO-OTH27 CEO argues that innovation also occurs outside R&D	**4**	**4**	**0.3**
CEO-OTH 28 CEO argues that R&D should always be one step ahead	**1**	**1**	**0.1**
CEO-OTH29 CEO educates the firm's environment	**1**	**1**	**0.1**
CEO-OTH30 CEO argues that value is as important as market	**1**	**1**	**0.1**
CEO-OTH32 CEO should have firm belief in the product	**1**	**1**	**0.1**
CEO-OTH33 CEO considers patients as innovation drivers	**2**	**2**	**0.4**
CEO-OTH35 CEO needs to understand culture of science	**3**	**1**	**0.1**
CEO-OTH36 CEO needs to know how to lead scientists	**3**	**1**	**0.1**
CEO-OTH37 CEO's understanding of scientists is more important than being a scientist	**1**	**1**	**0.1**
CEO-OTH40 CEO needs bottom-up ideas in LFSR firms	**2**	**2**	**0.4**
CEO-OTH42 CEO argues that simple messages make for flawed decisions	**2**	**2**	**0.4**
CEO-OTH43 CEO – not R&D - should simplify the message	**3**	**1**	**0.1**
CEO-OTH44 CEO should make sure scientists can remain scientists (and not become managers)	**2**	**1**	**0.1**
CEO-OTH45 CEO should be very flexible	**2**	**1**	**0.1**
CEO-OTH46 CEOs should be/act transparent	**3**	**2**	**0.4**
CEO-OTH47 CEO can prevent a R&D knowledge gap by growing from within R&D	**1**	**1**	**0.1**
CEO-OTH48 CEO teaches R&D about business	**2**	**1**	**0.1**
CEO-OTH49 CEO does not need to be a scientist	**2**	**2**	**0.4**
CEO-OTH51 CEO balances R&D vision with the Board's vision	**2**	**1**	**0.1**
CEO-OTH52 CEO challenges R&D and is challenged by R&D	**3**	**2**	**0.4**
CEO-OTH53 CEO knows how to challenge R&D because of his experience	**1**	**1**	**0.1**

Legend: Nt: Number of times the concept or subthemes appears in the interviews; Ni: the number of interviews in which the theme appears; Ri: the ratio of Ni/Ntotal with Ntotal: the total number of interviews.

Table 5-10 Exclusive CEO themes

5.2.2.2 Interview observations

A more extended overview of the quotes raised during the R&D interview observations is available in Appendix P. It is divided in two parts. The first part discusses the interview observations as they relate to the concept of trust, while the second part addresses the

process of knowledge complexity reduction as both strongly emerged from the interviews.

5.3 Discussion

5.3.1 Literature based themes

The findings in the second part of this research show that the a priori literature based concepts of CEO-attitude, -attention, -commitment and –involvement reappear when R&D executives are asked about their perception of the role of their CEOs. CEO attitude-related themes such as the fostering of a culture of innovation, of internal communication and external collaboration to increase internal innovation emerged from the R&D interviews. This observation is corroborated by similar findings in the research literature that show that CEO-attitude is a major factor in innovation (Damanpour and Schneider, 2006). In addition, both CEOs and R&D executives find that it is important to have a clear direction and vision in which the innovation should take place and the boundaries in which this occurs. Another theme that is shared by CEOs and R&D executives is the commitment of the CEO to human and financial resources. This is not surprising because CEO commitment is crucial seen the considerable cash burn in these companies and the continuous resources required to conduct R&D. R&D executives also refer to CEO involvement as an important CEO role descriptor, but less strongly than CEO attitude and CEO attention. R&D executives do not perceive their CEOs as innovators (see Figure 5-3). This was also observed during the CEO interviews. Both R&D executives and CEOs see the role of the CEO as a factor that facilitates life science innovation in the firm.

5.3.2 Other themes

While the literature based a priori themes constitute approximately 50% of the themes emerging from the interviews (Table 5-1), other themes – originally developed by the CEOs during their individual interviews - are also recognized by R&D executives as important role attributes. Some of these themes are emphasized by the R&D executives such as the concept of trust and absorptive capacity (Figure 5-1 and Figure 5-3). Again, as was observed during the interviews with the CEOs, the concept of absorptive capacity did not emerge ‘as such’ but rather through multiple references to the process of R&D knowledge complexity reduction.

Trust

The concept that R&D executives frequently and strongly elaborate on is the concept of trust. During the interviews, the R&D executives not only referred to the CEO’s attitude and attention to innovation, they also articulated the need to have their CEOs trust their capabilities.

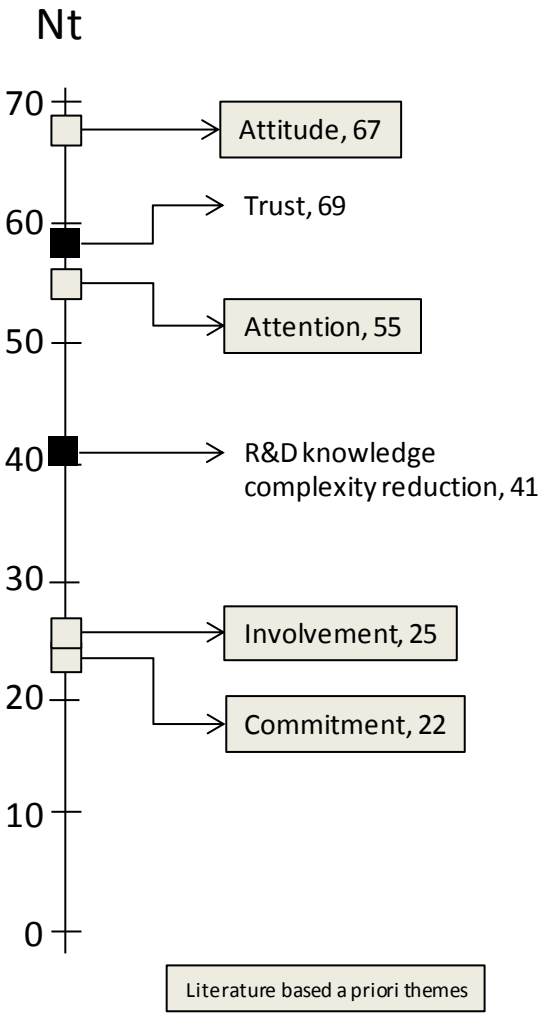

Figure 5-3 Ranking of themes according to their emergence during R&D interviews

First, trust is shared by CEOs and R&D executives but, as will be discussed in detail in the next chapter, with strikingly different emphasis. Trust has been defined as the 'psychological state that comprises the intention to accept vulnerability based upon positive expectations of the intensions or behavior of another' (Mayer et al., 1995). This psychological state goes a step further than a positive attitude towards innovation which was defined as the positional stance of openness to innovation. How important and relevant it may be for any firm wanting to innovate, in life science R&D firms, this general stance does not seem to be sufficient because its positive effect would disappear rapidly if trust was not present in R&D's capabilities. The positive attitude towards innovation – accepted by the R&D executives to be a *conditio sine qua non* - needs to supplemented with clear signs of trust role behaviours. The intention to accept vulnerability - which is core to the concept of trust - is an indispensable psychological state in life science R&D firms seen the impressive failure rates of innovation projects in these firms (Rosier, 2013). In other words, the attitude of 'having a positive stance towards innovation' is only a weak position in view of the considerable risks associated with life science R&D

firms (ranging from project failure and large financial losses to company death). According to the R&D executives therefore, trust is pivotal and therefore frequently emphasized. In addition, the concept of trust, as argued by the R&D executives, also seem to point to a relationship of trust rather than to a culture of trust. These are necessarily linked to each other but in the case of R&D executives this dyadic form of trust seems to be a key factor in how they see the role of the CEO. As argued by Dovey, 'trust is never an impersonal commodity' and 'through inspirational communication, knowing and believing in their "followers" and principled personal example leaders mould strong interpersonal bonds'. Trust also requires 'significant face-to-face time' (Dovey, 2010) and is 'embedded in relationships between people' (Nahapiet, J. and Goshal, S., 1998) In other words, it seems that R&D executives argue that their CEOs should clearly accept – or at least share - the vulnerability caused by the high uncertainty associated with the activities of the R&D function[14].

Second, the concept of trust could have been assigned to the a priori literature of attitude in Chapter 3. However, in view of the above and because of its clear and striking emergence in R&D interviews, it is argued that it has value in its own right and should not be 'masked' by the a priori concept of attitude. It is therefore considered a separate theme that supplements the more 'mundane' and general concept of attitude. This research points into the direction that trust is a concept that describes the role of the CEO in a life science R&D firm – seen their risk profile - more precisely than the generalized concept of attitude.

Third, trust requires learning and is more easily enacted 'in a culture where change is underpinned by openness to learning and self-renewal' such as a culture of innovation (Dovey, 2010). The theme of learning between CEO and R&D is frequently recurring theme during the interviews. It shows that learning, i.e. making sure that the CEO understands the specialized R&D know-how (and informing R&D about the market by the CEO) is an important construct in the mind of R&D executives.

Trust can only develop between two agents if the knowledge available to both is shared such that it is open to an understanding for both. It is built 'through the development of shared cognitive frames of reference via participation in a variety of overlapping networks' (Dovey, 2010). Such shared frameworks 'facilitate the flow of knowledge and develops the absorptive capacity of the collective' (Nonaka and Takeuchi, 1995). When two agents discuss a package of knowledge that has been adapted or transformed for the party with less knowledge to equilibrate his/her absorptive capacity, then learning follows and trust develops. In other words, trust can be developed between two agents if knowledge is made available to the agent with less knowledge that is in line with his/her absorptive capacity.

[14] This was also observed by the INSEAD researchers Loch et al. (2011) in their working paper 'Supervising Projects you Don't Understand' in which they refer to 'trust' as a basis of the relationship between CEOs who do not understand the knowledge of their top scientific management. This paper became available after the start of the writing process of this thesis.

Complexity reduction

During the interviews, R&D executives address the concept of trust and link this to the concept of knowledge such that CEOs with limited or no knowledge will need to show trust when they interact with the R&D function. CEOs with limited prior knowledge in R&D have limited absorptive capacity and therefore will need to trust their R&D function more than CEOs with considerable prior knowledge. However, even when CEOs have considerable knowledge in the R&D taking place in their firms, R&D executives still require trust to be present. For example, RDE21 is a chief scientific officer (and a university Professor) who reports to a CEO who holds a PhD in molecular biology (CEO6) and whom he/she regards high from a scientific point of view (see also Appendix P) argues that:

> *'I've seen other CEO's in my previous life who didn't know the science so well and I think that is a limitation, if such persons completely have to trust their CSO...'*

But even for CEO6, R&D knowledge is simplified by RDE24:

> *'I do simplify the message ... I do that yes unless he asks more specifics and then I explain in more detail. I speak in a different way with him such that the knowledge becomes absorbable and speak with him other than I do with my team'*

Although R&D executives agree on the need for trust and the fact that complex R&D knowledge needs to be simplified, they do not agree on the level of prior knowledge – a constituent of absorptive capacity - required from their CEOs. There is a large variation of prior knowledge requirements, ranging from no knowledge about the science to considerable knowledge of the R&D that takes place in the firm. The interviews did not allow – because of time constraints - to explore in detail what R&D executives expect from their CEOs when they refer to his/her knowledge.

Based on the results presented above, it can be concluded that – answering the first question – that the a priori themes used by CEOs to describe their roles are also recognized by R&D executives can be answered positively, with the exception of CEO innovativeness. The second research question whether the R&D function uses concepts to describe the role of the CEO other than those used by CEOs can also be confirmed. It is argued that to be the concept of trust.

The research data above however become increasingly interesting when they are contrasted with the CEO interview observations and discussed from the perspective of *both* CEO and R&D. Therefore the discussion of this chapter is continued in Chapter 6.

5.4 Summary

The role of the CEO in innovation as perceived by R&D is similar to the role of the CEO described by CEOs. The themes shared by CEOs and R&D executives are the a priori

literature based concepts of CEO-attitude, -attention, -commitment and -involvement. Also, R&D executives do not perceive their CEOs as innovators in their own right, an observation which was also made by the CEOs during their interviews. It means that the role of CEOs as described by R&D is aligned with the role of the CEO as described by the CEOs. R&D executives also recognize the need for complexity reduction and in doing so recognize the CEOs' absorptive capacity as they titrate their knowledge to his/her absorptive capacity. R&D executives however forcefully and frequently address the concept of trust in their relationship with the CEO. Because R&D executives clearly emphasize the concept of trust (in innovation by R&D) and because it is viewed as a considerable component of the role that a CEO should discharge in life science R&D firms, it is considered a new theme. Based on these observations at this stage of the research, the role of the CEO can further be described as follows:

'The CEO leads innovation in life science R&D firms by creating a bond of trust with the R&D function. This trust bond is formed as a result of the increased understanding of the CEO of the knowledge generated by R&D using his/her absorptive capacity and by creating a frame of reference in which that knowledge can be shared and understood'.

The key findings are summarized in Table 5-11 below.

	Themes addressing the role of the CEO in innovation as they emerged from individual structured interviews of R&D executives						
	A priori themes from the literature					**New themes**	
	ATTITUDE	**ATTENTION**	**COMMITMENT**	**INVOLVEMENT**	**INNOVATIVENESS**	**CEO ABSORPTIVE CAPACITY**	**CEO TRUST**
CEO	+	+	+	+	-	+	+

Table 5-11 The a priori themes and new themes observed during the R&D interviews

6 Comparing views of CEOs and R&D executives

6.1 Introduction

Both the first and second part of this research offered insight in how CEOs describe their role in innovation in life science R&D firms and how R&D executives perceive the CEO's role. Both CEOs and R&D executives share a set of common themes such as the need for CEO-attitude towards innovation, attention to the environment and the future and commitment to innovation. It was also shown that CEOs emphasize the need to reduce the complexity of the R&D knowledge, while R&D emphasizes the need to reduce the complexity in view of the CEO's prior knowledge. As a result of this finding, the concept of CEO absorptive capacity was introduced, i.e. the capability of the CEO to absorb and evaluate new R&D knowledge based upon his/her prior knowledge. R&D also expects the CEO to trust its innovative explorations. While Chapter 4 and 5 presented the perspective of the CEOs and of the R&D executives respectively, this chapter attempts to contrasts and analyze these perceptions. It starts with a discussion on theoretical saturation (Section 6.2.) and proceeds with a comparative analysis of both observations (Section 6.3.) which are summarized in Section 6.4.

6.2 Theoretical saturation

In order to compare the data from the research on the CEO and on the R&D executives, the collections of themes that emerged from both interviews should be 'complete'. It would be inappropriate to compare both data sets if themes would be missing from any collection of themes. In other words, it is necessary to ascertain that theoretical saturation is achieved for as well the CEO as the R&D interviews.

6.2.1 Theoretical arguments

Theoretical saturation is described as a process whereby a researcher 'continues to sample relevant cases until no new theoretical insights are being gleaned from the data' (Glaser and Strauss, 1967). According to Bryman (cited by Baker and Edwards, 2012), 'such an approach to sampling is very demanding because it forces the researcher to combine sampling, data collection, and data analysis, rather than treating them as separate stages in a linear process' and 'the researcher cannot possibly know at the outset how many cases he or she will need to collect data from, which causes problems when trying to formulate a research proposal'. In the case of interviews of CEOs, the problem is also hampered by the difficulty of obtaining access (Yadav et al. 2007). In other words, even if it would be possible to theoretically determine the number of cases, it is not sure whether the number would be attained in a real life research setting. Guest et al. (2006) (cited by Bryman, 2012) interviewed women in 2 West African countries and found that saturation was attained after 12 interviews. According to Bryman, 'this might appear quite a low figure but the sample was quite homogeneous (women at high risk of HIV) and the research was tightly focused'. In this case, theoretical saturation could be achieved because the sample was tightly controlled within strict boundaries of sampling. As few guidelines are available on how to establish theoretical saturation, Bowen et al. (2008) (cited by cited by Baker and Edwards, 2012) propose two stages,

which they employed during two health related projects, consisting of an initial sample of around 10 cases followed by a further three cases to determine if any new themes emerge, thereby corroborating Guest et al.'s point of view.

Based upon Guest et al.'s and Bowen et al.'s arguments, it could be argued that the 15 CEO interviews – which were preceded by 2 pilot interviews - should lead to theoretical saturation because the interviewed CEOs constituted a narrowly selected research cohort and form a group enclosed within a narrow community of life science R&D firms with similar risk profiles and sizes. In line with Guest et al.'s argument, it can therefore be assumed that theoretical saturation is obtained after the CEO interviews. In the case of the 33 interviews of the R&D executives, Warren's suggestion (Warren, 2002) that 'the number of interviews need to be between 20 and 30 for an interview-based qualitative study to be published', offers at least theoretical assurance that theoretical saturation is reached for the research interviews of the R&D executives. Realizing that there is no formal approach that allows the determination of a minimal number of cases (Baker and Edwards, 2012) it is argued here that, from a theoretical point of view, theoretical saturation is achieved.

6.2.2 Data analysis

Seen the amount of data that was extracted from both research projects reported in Chapter 4 and 5, it was decided to also test empirically whether the interviews led to theoretical saturation.

6.2.3 Theoretical saturation CEO interviews

In order to test the hypothesis that theoretical saturation was achieved after the interviews of the CEOs, the data in Table 4-1 and Table 4-2 were rearranged and the number of new themes were counted that emerged after each CEO interview. The data were then plotted in a graph which is presented below in Figure 6-1. It shows that the number of themes that emerge from the interviews start to level off with the number of CEOs interviewed although a plateau is not reached: there is still a slight increase in the number of themes when the interview of the last CEO is conducted. However, whether a continuation of the interviews would lead to fundamentally new themes that would jeopardize the conclusions reached in Chapter 4 is doubtful. In light of the observation of Guest et al. (2006) that theoretical saturation was achieved after 12 interviews because the sample was tightly controlled, it is argued here that theoretical saturation was achieved at the end of the CEO interviews, seen the homogeneity of the sample (CEOs of small mid-sized firms, in life science R&D).

6.2.4 Theoretical saturation R&D interviews

The data in Table 5-1 and Table 5-4 were reorganized and the number of new themes were counted that emerged after each R&D interview. This was done as well for the themes that were shared by CEOs and R&D executives and for the themes that were identified as exclusive to the R&D executives. The data are presented in Figure 6-2.

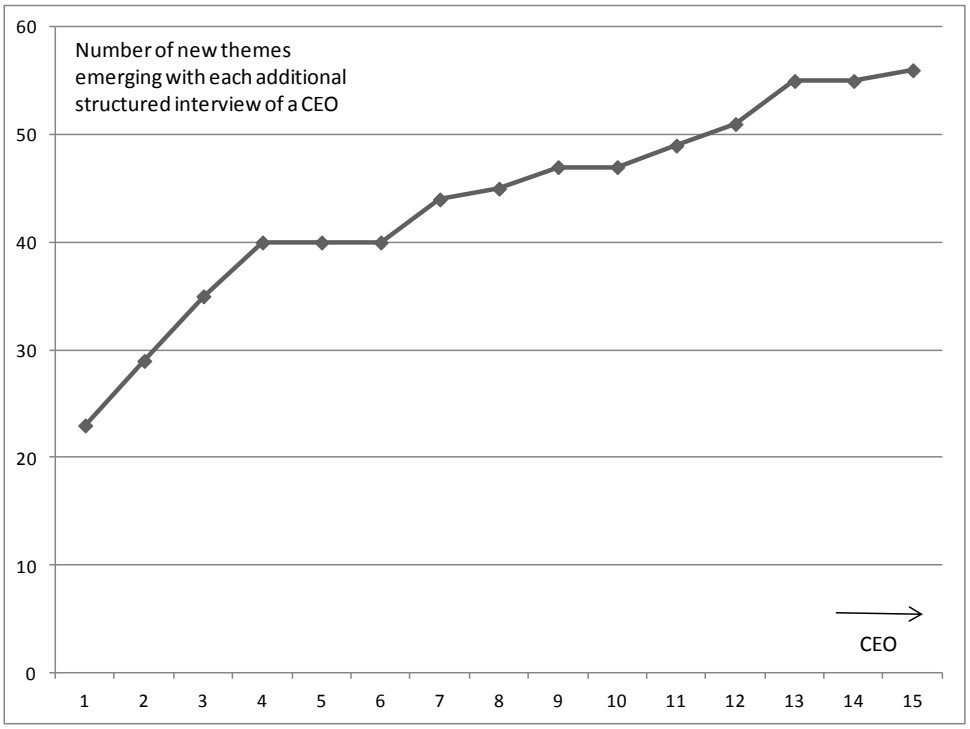

Figure 6-1 Theoretical saturation curve for themes emerging from interviews of 15 CEOs

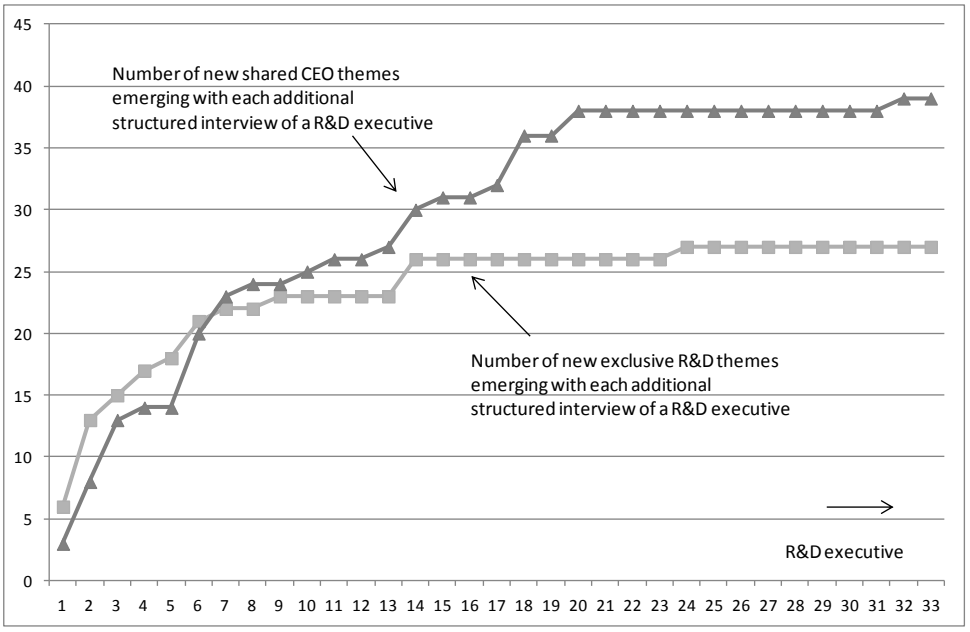

Figure 6-2 Theoretical saturation curve for themes emerging from 33 R&D interviews

The curves show that for the interviews of the R&D executives, saturation is achieved after approximately 15 interviews when the R&D-exclusive themes are taken into account and after approximately 20 interviews when the CEO-R&D shared themes are taken into account. Because it is argued that additional interviews would not generate new themes that would alter the conclusions and because both the CEO and the R&D

saturation curves show the development of a plateau after around 15 interviews, it is concluded that theoretical saturation is achieved to a level that allows comparison between both collections of themes.

6.3 Comparing themes and their emergence

This section addresses the themes that emerged from the structured interviews and the R&D executives. It is divided in a section on a priori themes and a section on 'other themes'.

6.3.1 A priori themes

It was observed during the CEO interviews and the R&D interviews that the role of the CEO in innovation in these life science R&D firms are perceived by both CEO and R&D executives by means of a common set of themes, i.e. those which were identified in the literature: attitude, attention, commitment and involvement. Both CEOs and R&D executives argue that they are crucial components of the role of the CEO (see Figure 6-3). The emergence of attitude, attention and commitment is not surprising as the absence of such role behaviors would be difficult to accept both by CEO and by R&D as they constitute the culture, the future and the resources required to innovate. R&D executives do not perceive their CEOs as product innovators but rather as facilitators of innovation which is also how CEOs perceive themselves. The setting of the goal and direction in which innovation should take place (i.e. CEO attention) are clearly recognized by both CEOs and R&D executives. During the focus group research, CEOs showed *how* they discharge this role: by using the de-complexified R&D knowledge they 'rally the firm behind the idea' (CEO3) and focus the R&D function. R&D executives also perceive their CEO's commitment as limited. There is no clear explanation for this difference but it may be caused by the fact that the R&D function, seen the continuous need for R&D resources, perceive their CEO's commitment (and his/her capacity to resource seen the difficulty of obtaining funding) as limited.

It was observed in the first part of this research that CEOs perceive their involvement as limited: during the CEO interviews they refer to NPD involvement only 7 times and 47 times if all involvement subthemes are taken into account. However, R&D executives refer to the involvement of their CEOs much less (in total, 25 times for 33 R&D executives and to NPD involvement only once). It points to the direction that CEOs tend to over-estimate their NPD involvement while their actual involvement as perceived by R&D executives is limited. This difference in self-perception by the CEOs with respect to their involvement and the perception by the R&D executives about the actual CEO's involvement is difficult to explain. When CEOs perceive themselves as involved in innovation while R&D executives do not perceive that behavior, the CEO's self-perception may actually be caused by the CEO's involvement at the start of the NPD process after which the CEO 'lets go' to allow the R&D executives to proceed with the project using their personal insight. This attitude of 'being involved at the beginning and then letting go' is raised by the CEOs (see INV7 'CEO is involved at the start of an R&D project and then delegates it', Chapter 4) and may cause them to perceive themselves as 'involved', while R&D executives who run the project for many months/years, do so

in the absence of the CEO and therefore perceive his/her involvement as limited (because they only involve him/her when things go wrong). This in turn may result in the R&D executives' reduced emphasis/emergence of CEO involvement during their interviews. In other words, they refer to their R&D projects as if the CEO 'was not around'.

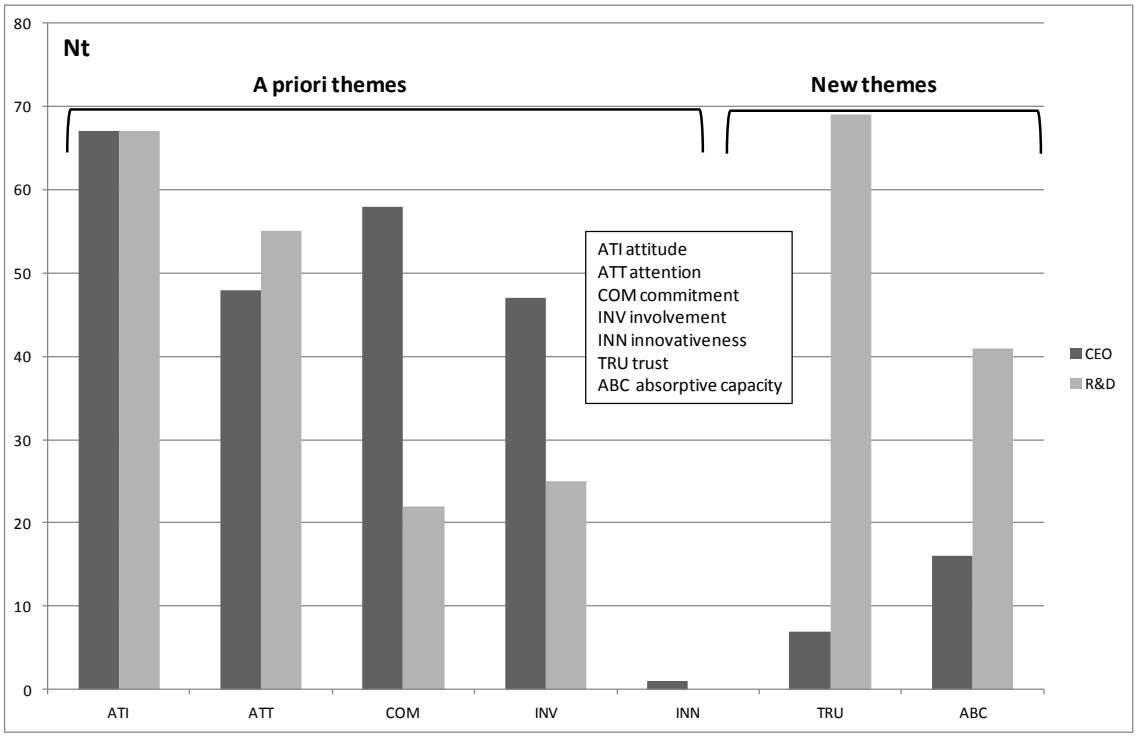

Figure 6-3 Comparison of themes between CEO and R&D executives

6.3.2 Other themes

6.3.2.1 Trust

While trust is a theme that is shared by both R&D executives and CEOs it appears in strikingly different levels (Figure 6-3). Even when caution is required to interpret the figures in the table above, it became clear during the interviews of the R&D executives that they considered trust a pivotal part of the role that a CEO should play in innovation in life science R&D firms. During the R&D interviews it became clear that the concept of 'trust' was a sensitive concept. R&D executives referred to it frequently and it emerges 'organically' during the discussion as if it were a fundamental concept that should be articulated clearly for the interviewer to be recognized. It was also observed during the 2 pilot studies when R&D executives stressed the concept of trust already from the start of the interview. In the mind of most - 24 out of 33 - R&D executives, trust plays a key role to describe the role of the CEOs. During the final CEO interviews, the theme of trust only emerged in one interview (the interview with CEO5) and only then as a concept that 'passed away' during the interview, i.e. it disappeared as quickly as it emerged and without any of the visual signs that accompanied the concept of trust during the interviews of the R&D executives. This indicates that trust seems to point to a specific

theme that differentiates the R&D function's view on the role of the CEO from the CEOs' view on his/her role. The majority of the CEOs do not refer to the theme of trust because they do not consider it to be of importance or because they consider it to be a given and of such a fundamental nature that it is not worth drawing attention to. Surprisingly, the concept of trust of the CEO in R&D was not reported during the discussions of the CEO focus group unless it was brought in the discussion by the interviewer. At this stage, the CEOs all seemed to be surprised that the concept of trust was laid on the table. They argued that trust is a concept that – in their context at least – is related to the level at which they challenge R&D. The level of trust and of challenge seemed to be related (CEO8):

> *'…it was very clear that I personally went over the board in trusting her too much and still it was not sufficient to her... so therefore I find this trust to be very complex... and it's very difficult to accept data and be offered data by R&D with the statement 'take it at face value'…'*

This was also perceived as such by R&D executives (for example RDE33) who argued that there is a fine balance between trust and challenge and that challenge can be strong without necessarily impacting trust negatively.

> *'....what I said at the beginning was that the very difficult balance between challenge and trust... so just enough challenge to trigger the conscience in the R&D organization ... that we constantly need to challenge ourselves, but not challenge to the point where it disrupts R&D and innovation, innovative activities that's what I mean really, so it's really the trust of the CEO into the R&D organization ... it sounds like 'leave it alone it's a black box', that's not what I mean...'*

Nevertheless for R&D, trust was bifocal: it concerned trust *by* R&D in the CEO (can we trust the CEO?) and by the CEO *in* R&D (does the CEO trust us?).

> *'...and yes it also works the other way around: there needs to be trust from the R&D side into the CEO that there is a sustainability in the approach to innovation …'*

The concept of trust in the CEO is based upon R&D's concern whether his/her knowledge about the market is of value for R&D and whether he/she is capable to take the right decisions based upon the knowledge that R&D generates.

It seems therefore that trust – from the viewpoint of R&D at least – is a function of prior CEO knowledge. If R&D learns from the CEO about the business context, trust in the CEO is developed. If the CEO learns from R&D, the CEO develops trust in R&D. This learning process is therefore linked to the CEO's absorptive capacity whereby knowledge is to be transformed to a level whereby both actors can interact in a meaningful way because they use a common knowledge base that lies the foundation for trust building. During

the focus group research, CEO15 argued – and this was supported by all present CEOs - that the reduction of the complexity of R&D knowledge is not only a 'simple simplification' of that knowledge but also constitutes a learning exercise for the CEO, in that he/she learns to ask the right questions (CEO15), to challenge R&D and to generate motivation (CEO15) within the R&D team because he/she is only capable to drive the company only if he/she understands the science that is taking place. In other words, it seems that in life science R&D firms, knowledge, trust and learning go hand in hand in the relationship between CEO and R&D. Because it is impossible for CEOs to keep pace with scientific developments, the knowledge gap with R&D remains and the R&D function expects the CEO's role to be one based on trust because he/she is not capable – because of time constraints or lack of (prior) knowledge – to fully grasp the details of the R&D knowledge which constitutes the innovative edge of the firm.

6.3.2.2 Absorptive capacity

The concern for the CEO's knowledge seems to be a domain (or theme) of the R&D executive, which is not surprising as they are the knowledge workers 'par excellence'. Depending upon the R&D executive, the need for scientific knowledge by the CEO ranges from the need for CEO expert knowledge, to CEO knowledge on new product development processes, to CEO prior knowledge on the topic of research to 'go along' with the discussion, to CEO basic knowledge, to no science knowledge (but eager to learn and understand) and finally to no scientific knowledge at all. It is not clear from the research interviews which knowledge requirements need to be fulfilled by the CEO in order to 'satisfy' the knowledge requirements of R&D.

The theme of CEO absorptive capacity – identified through the process of complexity reduction - is the second most frequently mentioned theme by R&D executives (it appeared 41 times during the interviews with the R&D executives, see Chapter 5). This observation corroborates the findings of the CEO interviews who argued that a de-complexification step is necessary to bridge the knowledge gap with R&D. R&D executives de-complexify R&D knowledge for CEOs who are in need of such de-complexification step. It is surprising to observe that RDE24, the chief scientific officer who reports to CEO8 who argued that such a de-complexification step is not necessary, finds the data communicated to CEO8 greatly reduced in complexity in order for CEO8 to make sense of it. When R&D executives find that such complexity reduction is not necessary it is because their CEOs are highly knowledgeable about the scientific R&D background. However, their CEOs still refer to the complexity reduction step and even CEO8 who argued strongly against the de-complexification step (because it may result in flawed decision making), agreed that it is required for CEOs to keep their R&D units in focus as to avoid it to become distracted into other topics of interest. The data show that the concept of complexity reduction and hence the construct of absorptive capacity is supported by the R&D executives.

While R&D executives address knowledge from the point of view of prior knowledge of the CEO (and through this to his/her absorptive capacity), CEOs address his/her prior knowledge (his/her absorptive capacity) through the need of the complexity reduction process. In other words both CEOs and R&D executives share the absorptive capacity

concept but address it from a different angle: the CEO from the need to reduce complexity in order to balance R&Ds' knowledge with his/her prior knowledge and R&D executive from the CEOs' prior knowledge and the effort required to titrate their knowledge to the CEOs absorptive capacity. By addressing each others' knowledge, CEOs learn from the R&D executives and by reducing the complexity of their knowledge R&D executives learn how CEOs thinks and what he/she knows(about markets, opportunities). Doing so both learn from each other.

6.3.3 Small versus large firms and impact of gender

No difference could be observed between themes emerging from interviews of CEOs of small and large forms and from interviews from R&D executives of small and large firms. Both CEOs of the larger firms addressed the concept of knowledge through the theme of complexity reduction while the R&D executives stressed the importance of both complexity reduction and the need for CEO trust. For reasons of anonymity it is impossible to divulge the data, quotes, themes and arguments raised by the (only) female CEO. However, based on the data there is no difference observed in the nature of the themes that could be assigned to gender.

6.4 Summary

CEOs and R&D executives share a number of a priori themes that describe the role of the CEO in innovation in life science R&D. The attitude of the CEO, his/her attention to the environment and the future and his/her commitment are crucial components of the role of the CEO and it is recognized by both CEOs and R&D (Table 6-1). The CEO's involvement in innovation is recognized by R&D executives ('**<**' in the table) but CEOs tend to over-emphasize it ('**>**' in the table). Both CEOs and R&D executives do not recognize the role of the CEO as the main innovator in the firm.

Both CEOs and R&D executives refer to the process of complexity reduction and therefore share and recognize the concept of CEO absorptive capacity. CEOs and R&D executives also share a number of other - newly developed - themes but do so with strikingly different emphasis or focus. CEO trust is strongly emphasized by R&D executives as a crucial part of the role of the CEO, while CEOs do not - or only marginally - use the theme to describe their role in innovation. Although both CEOs and R&D executives recognize the concept of CEO absorptive capacity, they differ in the emphasis on knowledge and learning. While CEOs refer to general themes of innovation management (attitude etc..) when discussing their role in innovation, R&D executives refer to the concept of knowledge but they strongly differ in opinion about the need for prior scientific knowledge.

	Themes addressing the role of the CEO in innovation as they emerged from individual structured interviews of CEOs and R&D executives						
	A priori themes from the literature					New themes	
	ATTITUDE	ATTENTION	COMMITMENT	INVOLVEMENT	INNOVATIVENESS	CEO ABSORPTIVE CAPACITY	CEO TRUST
CEO	+	+	+	>	-	+	-
R&D	+	+	+	<	-	+	+

Table 6-1 Comparison of CEO and R&D perceptions about the role of the CEO

7 Discussion and conclusion

7.1 Introduction

At the end of this thesis it is appropriate to return to the question raised in Chapter 1 where the overall inquiry of our research was presented as follows:

> 'How does a CEO discharge his/her role in innovation in the context of a life science R&D firm?''

More specifically, it was asked whether CEOs play a role in innovation in the research and development of drugs, vaccines or diagnostics. It was argued that it is generally believed that they do, but also that it is not clear how this is achieved and – if such a role exists – how it is discharged. In order to investigate that role, a systematic review of the literature followed and it became clear that the study of the role of the CEO in innovation was conducted using quantitative surveys whereby CEO characteristics and leadership styles were linked to measures of firm innovation. It was then argued that this quantitative approach misses valuable information seen its rather unidirectional approach and it was decided to take a more inquisitive route by addressing the CEOs directly, to include R&D and to take a qualitative rather than a quantitative approach. Our objective therefore was to increase our understanding of the role of the CEO by asking CEOs *directly* how they see their role and checked their understanding against the perceptions of the R&D function. In other words, our objective was to create an understanding on what CEOs do to play a role in innovation in life science R&D firms and how this can best be described.

The following paragraphs discuss the role of the CEO as observed from our interactions with CEOs and R&D executives (see below 7.3.) and inquire whether these observations can be generalized (7.4.). A separate paragraph uses the observations to develop a conceptual framework using Arendt's CEO-Adviser model (7.5). The chapter ends with a final conclusion (7.6) and offers future research avenues (7.7). But first the research design is reflected upon in paragraph 7.2..

7.2 Reflections on research design

7.2.1 Purpose, method and outcome

In Chapter 3. Research design, a table was introduced to link purpose, method and outcome (Table 3.6.). The question what CEOs do to lead innovation in life science R&D firms remains unanswered when researchers focus on quantitative survey-based research. This is because the actual role remains 'undiscovered' or may only be inferred or assumed from the relationships between predetermined variables (e.g. transformational leadership behavior of the CEO and firm innovation) or from the identification of (leadership or demographic) factors that may or may not impact innovation. What CEOs '*actually do'* can only become known if they are asked '*what they do'*. A description of the role of CEOs in innovation in life science R&D firms can only become known if the CEOs are approached directly through interviews and

conversations. Therefore there is a direct linkage between purpose (what do CEOs do?), method (asking the CEOs directly through interviews) and outcome (a detailed role description). The table below shows that the purpose of the study and the methods are aligned with the outcome of the research project in that the original research questions are addressed using appropriate methods (Table 7-1).

Purpose	*Method*	*Objective*	*Outcome*	*Cumulative outcome*
To better understand the role of the CEO in innovation in life science R&D firms	*Research interviews of 15 CEOs*	*To obtain a description of the role of the CEO in innovation as seen by CEOs*	*A description of the role that CEOs play in innovation in a R&D life science setting as viewed by the CEOs*	*a description of the role that CEOs play in innovation in a R&D life science setting as viewed by the CEOs*
	CEO focus group of 4 CEOs to which the observations of the individual CEO interviews are presented	*To inquire whether CEOs agree among themselves about the described role by each of the CEOs*	*To find support by the focus group CEOs for the statements made individually by the their colleague CEOs thereby supporting the validity of the research observations during the individual CEO interviews*	*Insight of the CEO's role in innovation as seen not only by individual CEOs but also accepted as core roles by a group of CEOs*
	Research interviews of 33 R&D managers reporting to the 15 CEOs	*To inquire whether the role description offered by the CEO is perceived as such by R&D*	*To ascertain the validity of the research observations during the individual CEO interviews by using the R&D manager's point of view on the role of the CEO thereby avoiding potential bias from the part of the interviewer*	*Insight of the CEO's role in innovation as seen by CEOs and corroborated by their R&D executives*

Table 7-1 Alignment of purpose, method and outcome

7.2.2 Limitations

Although it is argued above that quantitative based surveys would not offer insight into the actual role of the CEOs, one of the limitations of this study stems from the qualitative approach. The CEOs and their R&D executives have been interviewed during a relatively short time period and although they were quite open to interaction and exchange of ideas and appreciated the conversation, one should realize that the propositions made by both only reflect a fraction of what they could have argued and of what is on their mind. Although it was tried to minimize the impact of the limited time span by creating well prepared structured interviews, by bringing the CEOs back together in a focus group research and by obtaining agreement of as many R&D executives as possible, it should be recognized that the data obtained should be viewed in that regard. On the other hand, the data were obtained by means of a structured interview developed by means of an innovation framework that included as many innovation parameters as possible as to prevent potentially interesting concepts to disappear or to not emerge if they were present. Although this research is on an exploratory nature it does not diminish the need for validity. The focus group research was introduced to ascertain that the conclusions of the individual CEO interviews would prove justified.

In addition, while the research introduced a focus group of CEOs to inquire whether the data obtained during the individual CEO interviews would be supported during an interview session of 4 CEOs (which they did and even reinforced), a focus group research with the chief R&D scientists was not conducted and therefore it is not known whether

the observations made by the individual R&D interviews would have been supported during a focus group of the chief R&D scientists. This could have thrown light on the wide range of different opinions among R&D executives about the need for CEO prior knowledge.

7.3 Describing the role of the CEO in innovation

7.3.1 CEOs make use of their absorptive capacity

It was found that CEOs need to make considerable use of their absorptive capacity in order to be able to play a role in innovation. They evaluate R&D knowledge after it has been reduced in complexity by R&D. Core to the R&D knowledge transfer research and its application in the R&D-CEO interface, is the concept of 'knowledge distance' which is the 'degree to which the source and recipient possess similar knowledge' (Cummings and Teng, 2003). Knowledge distance is also referred in the narrow sense as cognitive distance (Nooteboom, 2010). According to Cummings and Teng, for R&D knowledge transfer, 'a particular difficulty is that the R&D contexts of the source and the recipient can be quite different. The R&D output of the source is often the R&D input of the recipient, and there may hardly be any other overlap between the R&D activities of the two parties'. In the field of knowledge transfer among firms, Dougherty argues that 'shared interpretation of knowledge is essential for collaboration in R&D activities', while Hamel considered that the knowledge distance or 'knowledge gap' between two parties cannot be too great because too 'many learning steps will be required if the knowledge gap (or distance) is significant' (Hamel, 1991; Dougherty, 1992). It is believed that overlapping areas of expertise facilitate knowledge transfer (Nonaka and Takeuchi, 1995). As Hamel (1991, p. 97; cited in Cummings and Teng, 2003) put it, this knowledge gap is linked to the concept of learning: 'if the skill gap between partners is too great, learning becomes almost impossible', as the recipient may be unable 'to identify, if not retrace, the intermediate learning steps between its present competence level and that of its partner'. Alignment in terms of knowledge is necessary for knowledge transfer (Dinur et al., 1998). In this regards, the concept of 'absorptive capacity' was developed to study the transfer of know how between two or more organizations, which means that firms differ in terms of their ability to learn[15] (Cohen and Levinthal, 1990; Lyles and Salk, 1996; Szulanski, 1996). Until now absorptive capacity was predominantly explored as a phenomenon between organizations. Only a few studies have used qualitative approaches in studying absorptive capacity either as a process exploration (Easterby-Smith et al., 2008) or to gauge impact of top and middle management leadership on absorptive capacity (Sun and Anderson, 2011).

The concept of absorptive capacity may also apply in the relationship between R&D and CEO. As we have seen in the outcome of our research some CEOs have knowledge about the nature of R&D in the firm while some CEOs have no knowledge. However, in both cases, the CEOs argue that the information that is proposed to them needs to be simplified, because the nature of the R&D data and the pace at which it develops has

[15] The concept of absorptive capacity has been re-defined frequently (Zahra and George, 2002 and Todorova and Durisin, 2007) but the original concept of Cohen and Levinthal is used in this thesis.

reached a level of complexity whereby even scientifically trained CEOs have difficulties understanding the intricacies of the data offered to them. It may explain why one specific CEO (CEO8) had no difficulty in accepting and transferring the raw R&D data as his/her absorptive capacity may have been high and in balance with the knowledge giver, i.e. the R&D function. Cohen and Levinthal argue 'that the ability to evaluate and utilize outside knowledge is largely a function of the level of prior related knowledge. At the most elemental level, this prior knowledge includes basic skills or even a shared language but may also include knowledge of the most recent scientific or technological developments in a given field. Thus, prior related knowledge confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends'. According to Cohen and Levinthal, an organization's absorptive capacity 'will depend on the absorptive capacities of its individual members'. This means that it also depends – and potentially even more critically – on the absorptive capacity of the CEO. They define absorptive capacity as the ability of an organizational member 'to value, assimilate and apply knowledge' and Mowery and Oxley extend this definition by arguing that individual absorptive capacity is a 'skill needed to deal with the tacit component of transferred knowledge and needed to modify this imported knowledge' (Mowery and Oxley, 1995). In this light, Pedrosa and Jasmand have developed the individual equivalent of firm absorptive capacity (Pedrosa and Jasmand, 2012) and defined individual absorptive capacity as an 'organizational member's work-relevant capability to identify new knowledge, assimilate it, apply it, and disseminate it to other organizational members'.

However, few studies have paid attention to individual absorptive capacities as opposed to organizational absorptive capacity. Ko et al. (2005) for example studied the knowledge transfer between consultants and their clients, but no studies have been conducted to explore the absorptive capacity of CEOs. Also, for knowledge to be transferred effectively, knowledge source and recipients require direct and intimate interaction (Park et al., 2007). This is the case when CSO and CEO interact because the hierarchical difference between both is minimal but is not the case with middle-management R&D that is considered to be the locus of innovation (Burgelman et al., 2004). Ko et al. demonstrated that individual user's absorptive capacity plays a significant role in the knowledge transfer. In their study of perceived absorptive capacity of individual users, Park et al. (2007), define individual absorptive capacity as the ability of an organizational member to value, assimilate and apply new knowledge. They classify user absorptive capacity in three interrelated components:

- The user's capacity for understanding external knowledge. This component is strongly related to the member's prior knowledge base about the object i.e. 'when organization members possess greater prior knowledge, they can absorb new knowledge more effectively'
- The user's capacity for assimilating knowledge i.e. the user's ability to internalize new knowledge into his or her task environment. This is 'affected by how comfortable the user feels when executing the tasks using the technology'

- The users' capacity to apply the newly acquired knowledge i.e. not only the ability to understand and assimilate external knowledge but also the ability to exploit and commercialize.

In view of previous research in which CEO demographics and cognitive factors have been used to explore the role of the CEO in innovation and which were used to predict firm innovational performance, the concept of absorptive capacity shows considerable promise in that it potentially captures demographics and cognition in a single concept. As Cohen and Levinthal argue: 'the ability to evaluate and utilize outside knowledge is largely a function of the level of prior related knowledge'. This may only be achievable by CEOs with long tenure, experience in specific knowledge domains or business areas, with age or educational level etc., thereby encompassing these demographics and or cognitive capabilities into the concept of absorptive capacity. It can also be argued that a certain level of absorptive capacity of a CEO is a conditio sine qua non – at least theoretically – for a CEO to become attentive to opportunities in the internal or external environment, to become committed to and to become involved or even innovative in matters of R&D.

CEOs did not directly refer to the need for prior knowledge and if they did, they strongly disagreed among each other. When interviewed about their role in innovation, they referred to the process of the complexity reduction of knowledge, needed to have a meaningful discussion with R&D. This may explain the differences in opinion among R&D executives in their need for prior CEO knowledge. These differences may not be explained by differences in actual or perceived prior knowledge of the CEOs but rather by the different levels of CEO absorptive capacities perceived by the R&D executives. In other words, R&D executives who argue there is no need for their CEO to have strong prior knowledge in the field of science, may find their CEOs to have considerable absorptive capacity which is not necessarily caused by an appropriate educational background in science but by major experience levels or strong intellectual capabilities. In other words, CEO absorptive capacity is a concept that not only encompasses prior knowledge, experience, education, age but also the CEO's intellectual and cognitive capabilities or as one R&D executive commented during a post-interview talk: 'our CEO is not a scientist, has no experience in R&D but is a smart guy and learns fast'.

Figure 7-1 presents a scheme describing the transfer of knowledge between R&D and CEO. At the start of the process, the R&D function has knowledge which is complex (level b) and as such cannot be used for decision making by the CEO. The CEO may have prior knowledge from previous interactions with R&D or from previous experience but its complexity is lower (level a). In order to have a meaningful discussion, CEOs will need to base their decisions on knowledge from which the complexity has been removed and put in the context of a business proposition. This shared frame of reference is the end result of the transfer of knowledge from R&D to CEO.

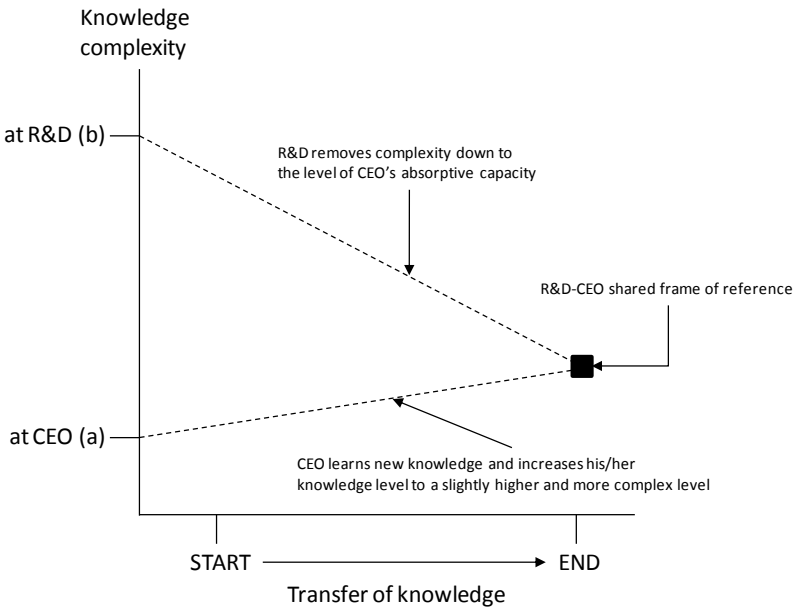

Figure 7-1 Transfer of knowledge between CEO and R&D

During this process, the CEO has learned new knowledge which may be used for future evaluations while R&D has learned to put his knowledge in a manner that allows evaluation. During the knowledge transfer, the complexity of the scientific knowledge is high at the level of R&D, but lower at the level of the CEO as the CEO, seen his/her background may only be capable to handle 'simple' R&D knowledge. When R&D simplifies the knowledge, it does so by 'titrating' its knowledge down to the level of the absorptive capacity of the CEO until a shared frame of reference is obtained such that the CEO and R&D reach a common understanding. During this process, the CEO has increased his absorptive capacity because he/she learned new knowledge that may act as prior knowledge for the new interaction with R&D.

7.3.2 CEOs use their absorptive capacity to create trust

According to Dovey, by creating a shared cognitive frame of reference, trust in newly communicated knowledge is built between acceptor and sender because of the increased understanding of the shared knowledge while the absorptive capacity of the knowledge acceptor for new(er) knowledge improves as a result of the learning process (Dovey, 2010). This research has shown that while CEOs refer to knowledge by referring to the need for complexity reduction and re-contextualization, R&D executives draw the researcher's attention almost exclusively to the concepts of 'knowledge' and 'trust'. While trust is a theme that is shared by both R&D executives and CEOs but with strikingly different intensity, the knowledge residing with the CEO seems to be an important domain (or theme) of consideration by the R&D executive, which is not surprising as they are the knowledge workers 'par excellence'. Their preoccupation with knowledge focuses on the (prior) knowledge of the CEO. Depending upon the R&D executive, the need for scientific knowledge by the CEO ranges from expert knowledge, to knowledge

on new product development processes, to prior knowledge on the topic allowing the CEO to 'go along' with the discussion, to basic knowledge, to no science knowledge - but eager to learn and understand - and finally, to no scientific knowledge at all. It is however not clear from the research interviews which knowledge requirements need to be fulfilled by the CEO in order to 'satisfy' the 'knowledge requirements' of R&D.

R&D executives link this need for CEO's prior knowledge to the concept of 'trust'. When a CEO has no knowledge at all about R&D – as was the case with CEO2P - there will be a considerable need to trust R&D. While trust is a frequently recurring theme during the interviews with R&D executives, it appeared only explicitly during one CEO interview (CEO5). No other quotes in the CEO interview-transcripts could be assigned to the 'psychological state that comprises the intention to accept vulnerability based upon positive expectations of the intensions or behavior of another' which is the scientific and generally agreed definition of trust (Mayer et al., 1995). In other words, during the CEO interviews, no CEO referred to his/her vulnerability as a result of the uncertainty associated with the activities of the R&D function. It was as if 'trust' was a concept that CEOs do not consider worthwhile discussing or mentioning. This is not necessarily surprising because others have already observed that CEOs of innovative firms do not consider themselves as risk takers. If management decisions are based on perceived rather than on actual risks, the CEO of an innovative life science R&D firm may not necessarily be a greater risk taker. On the contrary, according to Lefebvre and Lefebvre, innovative CEOs may be 'risk-reducers' as they appreciate their risky ventures better than CEOs who are not engaged in innovative programs and therefore consider themselves as 'risk-cautious' (Lefebvre and Lefebvre, 1992). Therefore the concept of trust – as the psychological state of willing to be vulnerable to the actions (risk taking) of others - and accept the risk associated with this vulnerability does not seem to be an important factor in their perceived role in innovation. Although the theme of trust appears only once during the interviews with CEOs, it does not mean that it is unimportant as they will not be able to function if trust with the R&D function were broken. However, it is the striking difference by which the concept of trust emerged between CEO and R&D executives that makes it worthwhile to draw attention to. When R&D executives discuss 'trust' they do so by referring to the concept of CEO knowledge, a concept used by CEOs indirectly through their reference to the need for complexity reduction of the knowledge received from R&D. From the viewpoint of R&D executives 'trust' seems to be a crucial element in their perception of CEOs. Because new life science knowledge develops fast, individual(s) who are not continuously updated about its developments are left behind very rapidly, thereby creating a knowledge gap between those 'who know and those who don't'. Because CEOs and R&D executives develop their knowledge in different fields (market and business vs science and technology) their respective knowledge bases will gradually diverge, thereby creating what is defined as a knowledge gap. It is therefore no surprise that R&D executives frequently refer to knowledge during their interviews and the potential gap that may be created between their knowledge and the CEO's. While CEOs reflect on generalized concepts such as attitude, attention and commitment that impact the firm as a whole, R&D executives point to a specific set of concepts that – from their point of view seem

to be crucial in their relationship with the CEO. As was argued by the R&D executives, the less he/she (the CEO) knows about the science, the more he/she will need to trust R&D because he/she will not be able to value their work and proposals because of lack of relevant knowledge and the inability to verify and discuss the data. It was observed above that by de-complexifying R&D knowledge for the CEO a shared knowledge base is created between CEO and R&D. According to Dovey 'trust is built through the development of shared cognitive frames of reference...' (Dovey, 2010). Therefore R&D executives, when referring to knowledge and the reduction of its complexity, refer to trust.

This is not contradictory to the data observed during the interviews of the R&D executives when some argued that it does not matter what knowledge background the CEO has (see Chapter 5 and Table 5-7). Knowledge of the CEO is not limited to scientific background knowledge but also to knowledge about the markets and more importantly to his/her capacity to absorb new knowledge that R&D executives generate. The more prior scientific knowledge the CEO has however, the higher his/her absorptive capacity for new R&D knowledge whereby trust is replaced by a process of verifiable data exchange and discussion. In other words, if the CEO and the CSO have the same scientific knowledge base, the need for trust is limited as the data can be verified, controlled, discussed and agreed upon as such. This is the case in start-ups and early life science R&D firms. An attempt is made to structure this relationship between trust, prior knowledge and absorptive capacity in Table 7-2.

Science knowledge differential between CEO and CSO:	**Knowledge CEO = knowledge R&D**	**Knowledge CEO ≠ knowledge R&D**
CEO-CSO Trust relationship:	Knowledge between CEO and CSO is a continuum: CEO and CSO have the same scientific knowledge base; therefore the CEO does not need a relationship based on trust as both knowledge bases are identical and data can be exchanged and verified, as is the case in any scientific discussion Trust is replaced by an exchange of verifiable and challengeable data	Knowledge between CEO and CSO is complementary: CEO and CSO have different knowledge bases. Data exchange and verification is hard to achieve. Challenge and verification of scientific data is possible but only to a limited extent seen the limited prior knowledge of the CEO: a trust relationship between CEO and R&D is required
CEO absorptive capacity:	Prior R&D knowledge of the CEO is high as is his/her absorptive capacity	Prior R&D knowledge of the CEO is low as is his/her absorptive capacity

Table 7-2 Absorptive capacity, trust and prior knowledge

This research indicates that the complexity reduction of R&D knowledge is a process whereby a shared cognitive frame of reference is created that facilitates the flow of knowledge between CEO and R&D. This process increases the CEO's individual absorptive capacity and – because of his/her growing understanding of R&D knowledge and because of new learning – develops trust in R&D (irrespective of his/her educational background or experience). In other words, the knowledge de-complexification step is not a simple 'simplification' of complex R&D data, it is an instrument that builds trust and develops absorptive capacity of the recipient.

Papadakis and Bourantas, in their study of the role of the CEO in innovation (Papadakis and Bourantas, 1989), already stated that managers should pay particular attention to the manner in which technological innovation proposals are presented to the CEO if they are to be successful in gaining the CEO's acceptance. Our research shows that the manner in which R&D knowledge is offered to the CEO may not only gain CEO acceptance but also generate CEO trust which is, according to Dovey (Dovey, 2009) 'the cornerstone of effective organizational leadership ... (the) significance (of which) in creating a milieu to innovate cannot be underestimated'. The fact that R&D executives refer to the theme frequently and forcefully shows that trust – from their point of view – is an essential element of the R&D-CEO relationship and reflects the need of R&D executives to receive clear signals from their CEOs that their relationship in view of the innovation is a trustworthy one. This means that although R&D executives are considered 'autonomous' and require 'freedom' to be innovative, trust in their work seems to play an essential role that supports that wish for autonomy and freedom.

Trust requires learning and it is more easily enacted 'in a culture where change is underpinned by openness to learning and self-renewal' such as a culture of innovation (Dovey, 2010). From this perspective, the concept of trust could have been assigned to the a priori literature of attitude and more specifically to the fostering of a culture of innovation, in Chapter 2. However, because its marginal appearance in CEO interviews and its clear emergence in R&D interviews, it is argued that the concept of trust has value in its own right and should not be 'masked' by the a priori concept of attitude. While attitude is a general conception that describes the role of the CEO and his/her 'positional stance towards innovation' and his/her 'tolerance to experimentation and failure', this research points into the direction that trust is a concept that describes the role of the CEO in a life science R&D firm more precisely than the generalized concept of 'attitude' because, as argued by Dovey 'failure to learn from experience destroys trust (i.e. particularly failures seen the low success rate in life science R&D, *comment inserted by this author*)' (Dovey, 2010). If R&D failures occur but are not learned from by the CEO because his/her absorptive capacity does not yet allow him/her to understand the underlying complexities of a failure in R&D, his/her trust in R&D will be affected negatively.

Because of the R&D executives' view that CEOs do not necessarily need to have expert knowledge, trust becomes an essential element in their relationship. Innovative ideas emerging from R&D may be accepted because the CEO's absorptive capacity allows him/her to correctly value the innovative idea or because he/she has trusts R&D's valuation because he/she does not have the necessary skills. Innovative ideas may be rejected because the CEO's absorptive capacity is either high in which case he found the proposal not sufficiently of value or low in which case he/she rejects it because he/she does not trust R&D. According to Nooteboom, 'trust is more needed to the extent that the people concerned differ in their cognitive structures and develop 'cognitive distance' that needs to be crossed if one is to collaborate with the other (Nooteboom, 2010). Cognitive distance, according to Nootebom, is as well a problem – because of the need to 'cross the cognitive bridge' – as an opportunity because of the new insights that can

be *learned*. This was supported by a non-scientist CEO who - when asked what the most important characteristic is of a CEO of a life science R&D firm - is his learning agility: his/her ability to learn, de-learn and re-learn. The ability to learn, de-learn and re-learn reflects the absorptive capacity of the acceptor of the knowledge and the learning process that supports it. In the latter case, the problem then is how trust can be built if knowledge is not present or cannot be calibrated to a level that data verification is possible. In line with Nooteboom, (CEO-) trust in data and (CEO-) verification of data then become each other complements and substitutes (Nooteboom, 2010). According to Nooteboom, cognitive distance 'yields both a problem and an opportunity' and that 'the positive side of cognitive distance is that it provides an opportunity for learning' (Nooteboom, 2010).

As stated above, trust has been defined as the willingness to be vulnerable (Mayer et al., 1995). This vulnerability is relevant in the highly vulnerable environment of R&D in a life science firm. Highly R&D intensive life science firms, depend primarily on the innovative R&D scientists in their midst: 'those capable individuals who unofficially sponsor the practices that lead to the realization of ideas that would normally be crushed , in spite of the risk that such informal action holds for their own future within their organization (Foster and Kaplan, 2001; Hamel, 2000; Pinchot, 1985; referenced by Dovey, 2009). R&D scientists who innovate make 'themselves vulnerable either by the rejection of their ideas (and associated embarrassment) and the lack of recognition from others (through their ideas not being taken seriously)' (Dovey, 2009). In this regard, R&D scientists face the challenge of their CEOs and associated reputation vulnerability. In other words, when R&D executives propose new ideas to their CEOs and top management team members, they are vulnerable to embarrassment as one R&D executive remarked during a post-interview talk:

> *'... we have some great ideas for great new products in the area of (therapeutic disease) and if we talk to patients about our ideas, they are utterly enthusiastic... but one cannot imagine how terrible it is to become ridiculed by top management when making the same proposal in the board room...'*

The challenge that R&D executives receive from their CEOs can be fierce if not embarrassing. The interviewed R&D scientists observed that the 'challenge-trust' balance is a delicate one as too much challenge may disrupt trust (RDE33, see Chapter 5). Uzzi demonstrated that in case of a good interpersonal trust relationship, the trustor does not collect, analyze the data offered to him by the trustee but makes decisions based upon limited information but steered by the level of trust available between both (Uzzi, 1997). Trust is a fragile resource in that whilst it is difficult and time-intense to create, it can easily and rapidly be destroyed. Trust was linked by the CEOs in the focus group to the action of challenge (see Appendix P and Chapter 4) and the question was raised in how far a CEO needs to fully trust R&D. The relationship between trust and challenge was also raised by R&D executives who argued that the balance between trust and challenge is a delicate one, as inappropriate challenge may lead to distrust. As was

argued by CEO8 however during the focus group meeting, there is no reason to accept R&D statements 'at face value' as too much trust may become detrimental for the firm and the CEO-R&D relationship. In an interesting series of experiments, Bidault and Castello (2010) observed that the effectiveness of innovation runs along an optimum of trust below which it starts to appear and above which it starts to decrease. Bidault and Castello found that as mutual trust increases between pairs of individuals in an experimental setting, the partnership's creativity went up, reaches a maximum and then starts to decline. They coined the creativity that was deployed within the pairs as 'partnership effectiveness'. It can be argued that a similar process appears when CEOs challenge R&D. At an optimal level of challenge, the creativity that emerges from the 'healthy' challenge leads to new ideas and the detection of opportunities that neither CEO nor R&D would have identified in isolation. However, if the level of challenge is low, the emergence of new ideas is solely associated with the R&D's group which may be caught or 'prisoned' in its own perspective. When CEO-challenge reaches a level that R&D perceives as a sign of distrust, both partners leave the room without new ideas or opportunity detection but rather with fixed points of view: the CEO with unanswered questions and doubts about R&D's innovativeness and R&D with a feeling of isolation and misunderstanding. When challenge is intense it can be caused either by expert knowledge of the CEO or the absence of it. In the first case, challenge may lead to fruitful discussions and the detection of alternative ways of thinking as is the case when R&D scientists - among each other- create innovation as a result of 'creative tension' (Bidault and Costello, 2010). On the other hand if intense challenge is not based upon CEO expertise knowledge but results from either a poor understanding or even suspicion about the value of the proposal and of the rationale and argumentation behind R&D's statements, this may result in distrust from the part of R&D. Bidault and Costello argue that 'trusting partners are more likely to commit the resources needed to implement the jointly developed ideas' thereby linking the concept of trust to the concept of commitment (for resources) as was also observed for absorptive capacity (Cummings and Teng, 2003). If it is observed experimentally that there is an optimal level of trust required for two partners to innovate and if R&D scientists argue that CEO-challenge can either build trust or destroy it, then it becomes clear that the level and extent of the challenge that CEOs use to discuss R&D proposals become a critical factor in firm innovation. This may also explain the variety of arguments used by R&D scientists about the need for CEO-knowledge. As was discussed above, R&D scientists differ in opinion about the required level of science-based knowledge of the CEO: ranging from expert knowledge to a basic understanding to no knowledge at all. This variety in the need of science-based CEO knowledge as perceived by R&D was explained by the variety of the R&D's perception of their CEO's absorptive capacity. R&D's need for science based CEO knowledge was driven by its perception of a low CEO's absorptive capacity while R&D's reduced need for science based CEO knowledge is driven by its perception of a high CEO's absorptive capacity.

In view of the observations made by the CEOs and the R&D executives, the wide variety of R&D's perceptions of the need for science-based CEO knowledge, explained by the range of their perceptions of CEO absorptive capacities may be caused by the different

ways these R&D executives are challenged by their CEOs. In other words, the way these R&D executives are challenged by their CEOs - i.e. whether the challenge creates or destroys trust - drive their perceptions of the CEO's absorptive capacities and their perceived needs for science-based CEO knowledge. For example, if R&D is challenged by the CEO such that the challenge is experienced as trust-building, because they can easily reach a shared frame of reference, then the CEO's absorptive capacity is perceived as high and the need for science-based CEO knowledge is not articulated as important. On the other hand, if R&D is challenged by the CEO such that the challenge is experienced as trust-destroying, because it is difficult to find a shared frame of reference, then the CEO's absorptive capacity is perceived as low and the need for (science-based) CEO knowledge is articulated as important. If CEO absorptive capacity is perceived as high, and a shared frame of reference can easily be found, the challenge can be intense and severe without creating distrust with the R&D function. This explains why CEOs with expert knowledge in the field and high absorptive capacity – such as CEOs in start-up firms - can fiercely challenge their R&D function, without the latter becoming distrustful of their CEO and – on the contrary – even become more motivated and innovative. It may also explain why firms equipped with excellent scientists and engineers are performing below their innovation capabilities because their CEO is not capable to challenge his/her scientists in a manner that motivates them, because his/her absorptive capacity is low and it proves extremely difficult to find a shared frame of reference in which fierce challenge can take place without destroying trust. In summary, CEOs with high absorptive capacity are capable to challenge appropriately and keeping a trust relationship with their R&D function.

7.3.3 CEOs use their absorptive capacity to focus R&D

During the interviews and the focus group discussions, CEOs argued that it is difficult to focus R&D and to retain it within boundaries to avoid it to diverge into non-strategically (but scientifically interesting) endeavors, seen the wide variety of R&D opportunities and the potentially interesting projects that exist within the firm. The creation and retention of focus was considered by the CEOs as a major challenge. The complexity reduction process helps CEOs to focus their R&D activities (as became clear during the CEO focus group meeting). On the one hand, the complexity reduction of knowledge serves the CEO

- to value the contribution from R&D and to become capable of evaluating it by creating an equilibrium of knowledge between CEO and R&D and to contextualize the R&D know-how
- to distill appropriate narratives out of the complex message that can be used to share with potential stakeholders and to focus R&D

On the other hand, the creation of such a simplified message also forces the R&D function to think and reflect about their activities and thereby check whether they are still aligned with the firm's objectives and with the R&D vision of the firm.

This bimodal character of complexity reduction was also supported by R&D executives who argued - along the same lines as the CEOs – that it helped them to keep focus. R&D did not see this complexity reduction as a waste of time. On the contrary, it was a worthwhile exercise as was stated by for example, RDE16:

> *'...the most important thing … is that if you do an experiment there is a certain goal in the experiment so I think the presentation of the results should be in the context of why did we do this experiment, (for which purpose) it has been intended to be used and so what are the results telling us in the big context so the presentation is a reductive presentation but it has a certain goal it is really what we wanted to do is that because we wanted to go there...'*

In other words, the complexity reduction process is more than a simplification or a trust generating concept. It is also a focus-generating concept, as well for the CEO ('ís this know-how aligned with our objectives or is its value such that it needs reassessment of our objectives?') as for R&D ('is our R&D and the new ideas that are being generated still in line with the company objectives and will it potentially generate value for the firm?'). In summary, the complexity reduction task required by R&D for the CEO is returned by the CEO to R&D as an instrument of focus.

All this does not mean that CEOs are presented with easy-to-swallow scientific data. As argued by CEO5 during this focus research group meeting, the most important characteristic of a CEO of a R&D life science firm is his/her 'learning agility', i.e. the capacity to learn, de-learn and re-learn. While the complexity reduction process is linked to the knowledge titration process that takes place between R&D and CEO whereby knowledge is transformed such that a shared frame of reference – a point of equivalence – is obtained between two actors with different levels of knowledge, it also serves the learning process of the CEO about the science that takes place and of the R&D about the business context.

7.4 Generalization of the observed CEO role

Our research was conducted in life science R&D firms characterized by intensive R&D. It means that the generalizability of the results is limited to their context and it may be difficult to extrapolate these findings to other industries with fundamentally different R&D paradigms such as IT and software development and where R&D investment and development time are much shorter than in life science R&D. However, it can be argued that the concept of absorptive capacity, the interaction with the R&D function and the building of trust and focus through the use of the CEO's absorptive capacity may prove to be a common concept driving the role of CEOs in innovation. Also, the question is valid whether the results can be generalized to firms outside of life science R&D firms. This research has led to conclusions which are highly relevant for life science R&D firms. The fact that these firms are all within a certain size (i.e. SME according to EU EMA definition) and that two big-pharma CEOs (more than 1000 employees in R&D) and their

chiefs of R&D were introduced without these having a different opinion when compared with the other CEOs of the smaller firms, shows that the generalization of the conclusions from small to large life science R&D firms can – at least tentatively - be accepted. Both the responses from the CEOs of the large R&D firms did not differ from those of the small firms: de-complexification of the knowledge was a main theme emerging from the interviews. In addition, their R&D chiefs were – as their R&D counterparts in the smaller life science R&D firms - primarily concerned about the CEO's knowledge and the trust required by them to interact with R&D. The question is valid whether the concepts retrieved from this study are applicable to other industries where complex knowledge is generated and complex developments take place. An industry that is also challenged by complex knowledge, considerable investments and long development times is the aviation industry. The question therefore can be asked whether these conclusion of this research are transferable to the aviation industry and research in this area may prove interesting.

7.5 The role of the CEO seen through a theoretical lens

7.5.1 Knowledge transfer

This chapter aims to put these findings against the background of current theory and to develop a conceptual framework of the role of the CEO in innovation in life science R&D firms. According to Cummings and Teng, a transfer of knowledge depends on the knowledge context, its articulability and embeddedness and the recipient context where learning culture and priority to the transfer are being set. In both cases people, roles and routines at the level of knowledge giver and at the level of knowledge acceptor determine the success of the transfer of the knowledge. Transfer is also steered by the context of the relationship between knowledge giver and knowledge acceptor and is determined by distance – either physical or organizational- and by contextual knowledge, norms and contextual activities (Cummings and Teng, 2003). Knowledge transfer success in the innovation literature, focuses on how knowledge is re-created in the recipient whereby transfer involves the re-creation of a source's knowledge package in the recipient (Nelson, 1993). According to Cummings and Teng, the problem with this re-creation is that knowledge can be embedded in 'many different structural elements of an organization, such as in the people and their skills, the technical tools, and the routines and systems used by the organization, as well as in the networks formed between and among these elements' (Argote and Ingram, 2000). Evidence is available that shows that effective re-creation also 'requires that the knowledge package is made accessible to or de-contextualized for the recipient so that the recipient can convert it, adapt it or reconfigure it to its localized needs' (Davadas and Argote, 1995; Dixon, 2000; Leonard-Barton, 1988; Moreland et al., 1996). The literature on knowledge transfer has focused primarily on the transfer of R&D know-how between organizations and a research model for knowledge transfer was proposed by Cummings and Teng. A successful transfer is defined by the degree to which a recipient obtains ownership of, commitment to, and satisfaction with the transferred knowledge, a process defined as

knowledge internalization and developed within institutional theory (Cummings and Teng, 2003; Meyer and Rowan, 1977).

The concept of *ownership* by the CEO is particularly applicable in the context of transfer of R&D knowledge from the R&D function to the CEO where the goal of the transfer is for the CEO to make decisions in view of the value creation that it may offer to the firm. Knowledge ownership (references cited by Cummings and Teng, 2003) means that

- greater discretion over the knowledge allows a recipient to invest more of their own ideas, unique knowledge, and personal style in the knowledge (Pierce et al., 2001)
- the intensity of the recipient's association with the knowledge (i.e. the number of interactions involving the knowledge) potentially affects its feeling of ownership
- an individual invests energy, time, effort, and attention in the knowledge (Csíkszentmihályi and Rochberg-Halton, 1981)

The second element of knowledge internalization is *commitment*. Commitment may be defined as a facilitating conception, in that it creates the specific circumstances for R&D to flourish, either by financial or human resources, infrastructure etc. The generation of science-based knowledge (the raw R&D data) described by one of the CEOs as the "lyrics" of R&D, is then recreated as "music" which – according to the CEO, can be appreciated and evaluated and constitutes the recontextualized science based knowledge (see Appendix I, CEO 4). The concept of R&D knowledge re-contextualization is linked to the a priori concepts retrieved from the literature review and used to conduct this research project. It shows that the leadership and innovation literature from which the a priori concepts were retrieved, is linked to the knowledge transfer literature through the a priori concept of 'commitment'. As was discussed earlier, commitment was defined as 'the act of committing, or putting in charge, to entrust, to bind to a certain line of conduct' (Thatcher and McQueen, 1980) and is therefore linked to action. According to Leonard-Barton and Mowday, individuals develop knowledge commitment to the extent that 'they see the value of the knowledge, develop competence in using the knowledge, maintain a working relationship or interaction with the knowledge, and are willing to put in extra effort to work with the knowledge' (Leonard-Barton, 1995; Mowday et al., 1979). In order for the CEO to make this formal *commitment* he/she requires 're-contextualized' knowledge from the R&D function in order for him/her to make strategic decisions.

The third aspect of knowledge internalization is '*satisfaction*'. Recipient satisfaction with knowledge is important 'because it can reduce the recipient's stress and resistance levels in adapting and using the knowledge' (Leonard-Barton and Deschamps, 1988).

In summary, only when a recipient internalizes knowledge can it be sufficiently understood and adapted by the recipient to allow for its effective re-creation and, ultimately, its use. Knowledge internalization therefore is an important conceptual

approach to study the role of the CEO in innovation as it may potentially show how knowledge embedded in R&D is extracted from its context and recreated into a form that allows the CEO to take ownership of the data so that it can be discussed at the level of the TMT, to become committed to and satisfied with the data so that it results in investments and further development.

7.5.2 Arendt's CEO-adviser model

Although it was not developed to understand the role of the CEO in innovation, Arendt's CEO model offers interesting perspectives to understand the role of the CEO in innovation (Arendt et al., 2005). According to Arendt et al., two models have been used to try to understand top-level organizational decision making.

The first model addresses the CEO as the unit of analysis and is presented as the 'CEO model'. However, 'to the extent that the CEO model focuses on CEOs as lone decision makers ... it is an atomized, undersocialized conception of human action' that neglects 'the CEO's social context' (Granovetter, 1985) and 'CEOs would wield their power and make unilateral decisions... despite needing to address multiple, conflicting goals and evaluate a myriad options' (Cyert and March, 1963).

The second model (the 'TMT model') used the top management team as the unit of analysis and depicts a decision making process that is shared by the TMT members. The concept resulted in a broad range of scientific investigations addressing TMT-conflict, TMT-consensus, TMT-demographics and TMT-composition among others. According to Granovetter (Granovetter, 1985 cited by Arendt et al., 2005) this model is an 'oversocialized conception' that 'does not recognize that TMTs tend to be hierarchical decision-making bodies in which involvement is not equal'.

In view of the two models presented above, Arendt et al. argue that 'many strategic decisions in many firms are neither made by a unilateral CEO nor by a TMT'. This is particularly the case in firms where the innovation expertise does not reside with the top management team or the CEO but rather in middle management (Burgelman et al. 2004). They therefore propose the 'CEO Adviser model' which 'blends individual and group decision making... by recognizing that individuals involved in strategic decision making may come from anywhere in the firm's hierarchy and may not be consulted on all decisions' and which, they argue, is 'more authentic'. The model involves four characteristics:

- the CEO as the principal decision maker,
- the advisers to the CEO who can be internal or external to the firm,
- the selection of advisers by the CEO, and
- the dyadic communication between the CEO and advisers.

According to Arendt et al., in the CEO Adviser model the CEO solicits information from different levels within and outside the organization, yet 'holds ultimate authority for the final decision and is accountable for it' (Sniezek, 1999), involves a complex social information search to identify strategic advisers and involves – according to Arendt et al (2005) - considerable CEO Adviser *trust (*emphasis by this author*)* and collaboration.

According to Arendt et al., the foundation of the CEO Adviser model rests on four assertions which are central to the management literature (Arendt et al., 2005):

- firstly, as the CEO is the final decision maker in the firm, the CEO is ultimately responsible for the firm's strategic decision making and accountable for its outcome (Finkelstein and Hambrick, 1996)
- secondly, the strategic decision making is characterized by ambiguity and complexity (Carpenter and Fredrickson, 2001) and is therefore subject to advise by the CEO from his/her advisers
- thirdly, there is a high potential for information overload or overreliance on extant mental maps (Cyert and March, 1963) as the 'type of information processed from a firm's environment is likely to be too great for any one person' (Arendt et al., 2005)
- fourthly, it is known that top managers rely on advice from social networks that include friends, customers, financial institutions, alliance partners, trade associations etc. (Collins and Clark, 2003; Gabarro, 1987).

Arendt's model is suitable for incorporation of our research results for the following reasons.

First, the model proposes that the CEO is the ultimate decision maker in the firm. This argument is independent of the firm's internal or external environment and therefore is also applicable in the context of life science R&D firms. It is the CEO who takes final decisions and searches for approval from the board.

Second, the CEO-Adviser model's assertion is that strategic decision making is characterized by ambiguity and complexity. This is especially true in the context of life science R&D where not only a myriad of options are available in setting the course of action but where the decision making process is complicated by the potential knowledge asymmetry between CEO and (R&D) advisers (Styhre, 2009).

Third, the 'type of information processed from a firm's environment is likely to be too great for any one person' and this generates potential information overload. This applies to environments of R&D, where the firm's operational and market information is complemented with a large and complex information data base originating from within and made available by the R&D function. For example, the choices that need to be made and which have major strategic impact are based upon a varied and complex knowledge base requiring careful examination and consideration from a technical, scientific, regulatory and marketing point of view.

Fourth, the model allows the study of the CEO in view of his/her interaction with social networks in and around the R&D function because it specifically addresses the importance of interaction with a group of advisers to the CEO and the trust required between both. This is highly relevant in the context of a life science R&D firm where the complexities of science make it highly unlikely for a CEO to take decisions unilaterally. Based upon the assumption that the role of the CEO in life science R&D may be driven by the interaction with the R&D function, Arendt et al.'s CEO Adviser model offers a

conceptual framework that is suitable and appropriate to conduct research in life-science R&D firms.

7.5.3 Arendt's CEO adviser model and R&D

The research reported above shows that the role of the CEO in innovation is driven by his/her absorptive capacity, necessary to have meaningful discussions with the advisers – the R&D function - in the firm. These advisers are not limited to the top management team but rather extend into the R&D function as was clearly stated by CEOs as by the R&D executives during the interviews. The diagram below (Figure 7-2) presents the CEO-adviser model as proposed by Arendt et al. and is adapted for the environment of a life science R&D firm. It consists of 4 distinct steps whereby the CEO

- gathers information from the different R&D advisers available at all levels in the firm. During this research it was shown that both CEOs and R&D executives argue that CEOs in these firms look for advice and knowledge at all levels and not only at the level of the CSO (step 1),

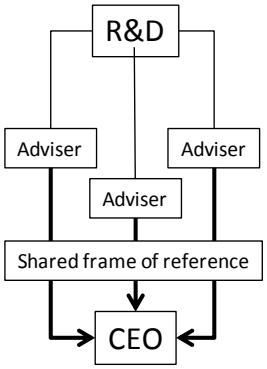

Figure 7-2 The creation of a shared frame of reference

- the CEO, together with the R&D advisers, process and interpret the R&D knowledge (step 2),
- the R&D function, because it has a full understanding of the scientific knowledge, its risks and potential opportunities, recommends a decision to the CEO (step 3),
- the CEO takes a decision (step 4)

In this process the advisers are described as originating from within the R&D function of the firm but they may come from as well inside or outside the firm, as has been reported by as well CEOs as R&D executives during the interviews.

By interacting with the advisers, the CEO can discharge his/her role in innovation, but only to the extent allowed by his/her absorptive capacity. It is at the level of information gathering and interpreting of information that the CEO's absorptive capacity becomes crucial. In other words, CEOs only play a role in innovation if they bridge the knowledge gap with R&D. In order to do so, the complexity of R&D knowledge is reduced and a shared frame of reference is created between CEO and R&D as represented in the figure above. Doing so, the CEO is capable to evaluate – i.e. process and interpret - new

knowledge even when the knowledge distance with the R&D function is high. The higher the CEO's prior knowledge, the higher his/her absorptive capacity, the less knowledge needs to be reduced in complexity.

7.5.4 The absorptive capacity – innovation cycle

The research above has shown that CEOs frequently refer to the process of complexity reduction in order to have a meaningful discussion with R&D. By making complex R&D data understandable to the CEO, the latter develops his/her absorptive capacity to absorb new(er) knowledge but also – because of his/her growing understanding of R&D knowledge – develops trust in R&D and is able to focus the R&D function.

The diagram in Figure 7-3 shows the linkage between firm R&D knowledge, the development of a shared frame of reference, CEO absorptive capacity, R&D focus by the CEO and CEO trust in R&D and the resulting impact on innovation. First, R&D knowledge (K1) is transferred to the CEO in a firm with minimal innovation (Imin). During this transfer process the complexity and science-based context are reduced and de-contextualized respectively, such that it is equilibrated with the absorptive capacity of the CEO (A1) driven by his/her prior knowledge. This leads to an understanding of the CEO of the scientific activities conducted in the R&D function and generates trust (T1) from the CEO in R&D as argued by Dovey (2009). This in turn allows the CEO to focus R&D, an activity that he/she would not be able to do if he/she would not understand R&D knowledge and *can* only do if he/she makes use of a de-complexified, simplified message. This leads to firm innovation because the R&D proposals are embraced by the CEO. When R&D continues to engage in innovation, it will transfer its knowledge (K2) to the CEO, who has now become more knowledgeable about the science, has developed a higher absorptive capacity (A2) and an increased trust (T2) because of his/her increased understanding and has become capable to focus – manage – his/her R&D function even better and to increase his/her commitment. The CEO embraces the idea and the firm innovation potential increases to an even higher level (Imax). By increasing his/her absorptive capacity through repetitive cycles of CEO-R&D interaction, the CEO's learning increases as well as his/her trust in R&D, which in turn will be perceived positively by R&D and result in innovative behavior. This cycle is presented as the 'CEO absorptive capacity innovation cycle'.

As defined in 2.3.4.2., CEO attention is the 'act of keeping one's mind closely on something or the ability to do this'. As argued by Yadav et al. (Yadav et al., 2007), the attention of the CEO on the future and on internal or external environment impacts the speed of detection and development of new technologies and explains why some top managers have a greater impact on innovation than others. It is argued that this 'attention to the future resulting in a focus on the internal and external environment' (Yadav et al., 2007) is moderated by the CEO's absorptive capacity. If the absorptive capacity of the CEO is high, he/she will be capable to 'sharpen' focus and draw the

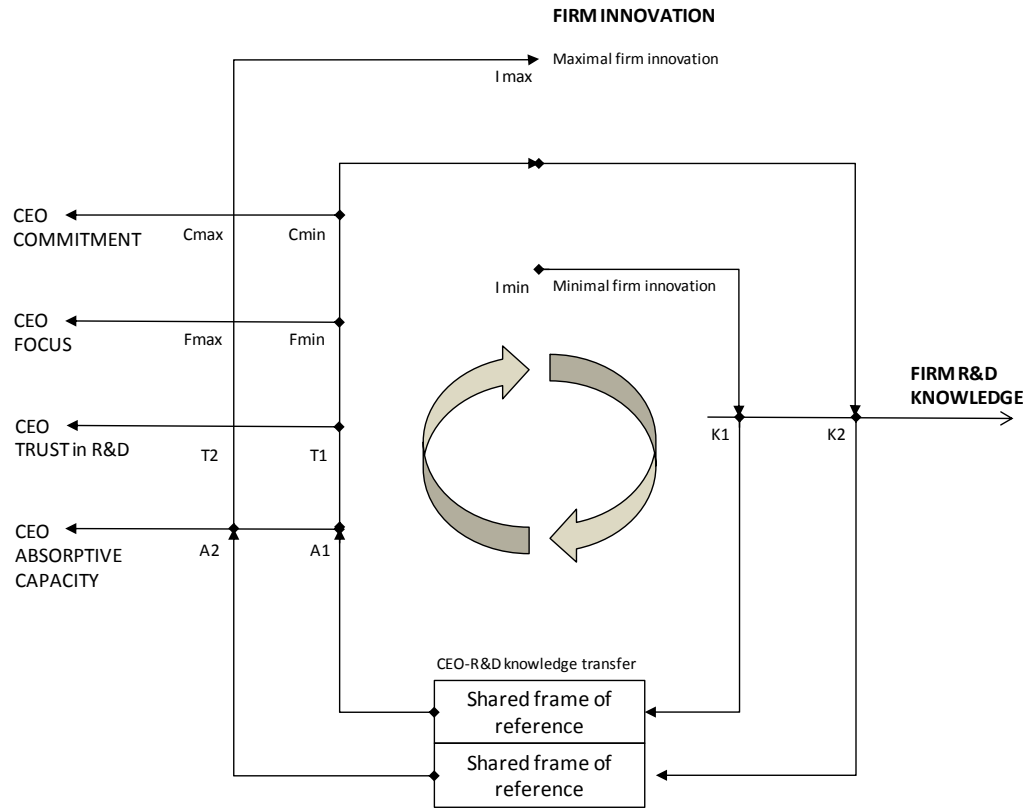

Figure 7-3 The CEO absorptive capacity – innovation cycle

organization's attention to specific innovative objectives. If the absorptive capacity of the CEO is low, he is able to increase it through repetitive interactions with R&D who transform complex messages in simple language thereby allowing the CEO to improve his/her absorptive capacity and increasing his/her capacity to focus the company on strategically promising objectives. In other words, the level of absorptive capacity of the CEO will drive the level of focus and - in turn - increase the precision by which financial and human resources will be made available. When Papadakis and Bourantas (1998) argued that managers should pay particular attention to the manner in which technological innovation proposals are presented to the CEO (if they are to be successful in gaining the CEO's acceptance), it should not be forgotten that the creation of the 'perfect' message for the CEO also enables him/her to create the 'perfect' focus for the firm. At the start of the cycle, CEOs can only focus the firm using a basic absorptive capacity leading to minimal or average innovation. However, after several cycles of interaction with R&D, the CEO's absorptive capacity increases and thereby allows him/her to sharpen the focus of innovation as his absorptive capacity increases. In addition, by developing his/her absorptive capacity, the CEO will also be able to appropriately challenge the R&D function without the risk of breaking a valuable trust relationship with R&D.

7.6 Conclusion

7.6.1 What is the role of the CEO in innovation in life science R&D firms?

CEOs play a role in innovation by acting as facilitators. They create a culture of innovation where R&D scientists are free to experiment, take risks and exchange ideas. They also make available resources and create organizational structures for innovation to occur. These CEO roles are presented in the literature as attitude, attention, commitment and involvement. CEOs do not play a role in innovation by becoming innovators themselves. However, for CEOs to play a role in innovation by discharging an attitude fostering innovation, by becoming attentive and involved in innovation and by being committed they need to make considerable use of their absorptive capacity. Without this, their role in innovation eventually disappears and will result in disengagement and abdication of responsibilities as was shown in the case study presented in the introduction (Chapter 1) (Loch et al., 2011). Therefore the first of our main conclusions is as follows:

> **It is not possible for a CEO of a life science R&D firm to play a role in innovation in life science R&D firms without actively employing his/her absorptive capacity**

CEOs also make sure that there is clear attention to the future and focus the firm's R&D within well-defined boundaries. CEOs acknowledge the presence of a major gap of knowledge between themselves and R&D. They make use of their absorptive capacity to bridge the gap and are assisted by R&D that de-complexifies knowledge to a level that is in equilibrium with the available absorptive capacity of the CEO, such that a common frame of reference is obtained that creates mutual understanding. This mutual understanding allows the focus of the R&D function because, as one of the CEOs argued, it, and the whole firm, can be rallied behind a simple idea. Therefore:

> **CEOs use their absorptive capacity to develop a frame of reference with R&D in which knowledge is shared and understood. This shared knowledge allows the CEO to focus the R&D function, even when he/she does not understand the intricacies of the science that governs the R&D**

The trust that is generated as a result of this frame of reference then becomes a source for more innovation because the R&D function feels confident that the CEO is capable to follow their scientific exploration and developments. Because the CEO has a better understanding of the R&D knowledge he/she will be better able to identify new innovational opportunities in the market or detect them sooner and as a result:

> **Because of the increased understanding of R&D knowledge, facilitated by the creation of a shared frame of reference, trust by the CEO in the R&D function is created which in turn fosters further innovation**

In short, the role of the CEO in innovation in life science RD firms consists in developing his/her absorptive capacity such that he/she is able to focus the R&D function, a responsibility the CEO can only take by using de-complexified R&D knowledge in line with his/her absorptive capacity such that a common understanding is achieved with R&D which leads to CEO trust in R&D, to commitment and hence to innovation.

7.6.2 Contribution to theory

7.6.2.1 CEO absorptive capacity in upper echelon research

In view of previous upper echelon research in which CEO demographics such as age and tenure were used to predict firm innovation, the use of individual CEO absorptive capacity shows promise in that it captures demographics, cognition, education and experience into a single concept thereby offering a more encompassing alternative to the use of singular CEO-proxies. Absorptive capacity can be considered a conglomerate of education, personal experiences, knowledge generated through successes and failures and intellectual capabilities. The concept encompasses a more coherent view than the CEO 'proxies' used in upper echelon research. As was observed, CEOs play a role in innovation by bridging the knowledge gap with R&D. In order to bridge the gap, the complexity of R&D knowledge is reduced such that a shared understanding is created between CEO and R&D. Doing so, the CEO is capable to evaluate new knowledge even when the knowledge distance with the R&D function is high and to identify innovational opportunities. This process takes place as the CEO makes use of his/her absorptive capacity or 'the ability of an organizational member to value, assimilate and apply knowledge' (Cohen and Levinthal, 1990). It also includes experience-based knowledge, knowledge obtained through education and through other sources. The higher the CEO's prior knowledge, the higher his/her absorptive capacity, the less knowledge needs to be reduced in complexity and potentially the faster innovational opportunities can be detected. In other words, the research has shown that CEO absorptive capacity is a promising new conceptual instrument to study the role of the CEO in innovation.

7.6.2.2 CEO absorptive capacity and trust

While CEOs do not refer to their prior knowledge as such when interviewed about their role in innovation but rather to the process of complexity reduction in order to have a meaningful discussion with R&D, R&D executives refer continuously to the CEO's prior knowledge and the need for his/her trust in their knowledge. In their study of organizational trust and knowledge transfer, Nonaka and Takeuchi (1995) argue that 'trust is built through the development of shared cognitive frames of reference which facilitate the flow of knowledge and develop the absorptive capacity of the collective with respect to knowledge transfer'. When R&D knowledge is reduced in complexity, a shared cognitive frame of reference is made that facilitates the knowledge flow between CEO and R&D. By making complex R&D data understandable to the CEO, the latter develops his/her absorptive capacity to absorb new(er) knowledge and – because of his/her growing understanding of R&D knowledge – may develop trust in R&D. In addition, the CEO uses the simplified knowledge as an instrument of focus for R&D. It is argued here that the knowledge complexity reduction process not only 'simplifies'

complex R&D data, but also builds trust, 'the cornerstone of effective organizational leadership ... (the) significance (of which) in creating a milieu to innovate cannot be underestimated' (Dovey, 2009) and focus the firm's R&D.

7.6.3 Contribution to practice

This research has important implications for managers. CEOs of small and medium sized life science R&D firms tend to invest most of their time and management effort into generating income to keep their firms afloat because such companies require considerable amounts of cash for funding research. At the same time biomedical science is progressing at a considerable pace and so current knowledge rapidly becomes outdated. In these circumstances, CEOs – even those with a biomedical background – who fail to continue learning, will find their capability to evaluate newer knowledge decreasing rapidly because their prior knowledge has not kept pace with developments in biomedical R&D. This will reduce their absorptive capacity and in turn lead their ability to accurately evaluate the business potential of emerging biomedical knowledge. Another key implication for CEOs is that they need to constantly refresh their knowledge - by a continuous interaction with R&D - if they are to be perceived by R&D as capable of driving innovation. If CEOs are not perceived as driving innovation then this will lead to R&D de-motivation and reduced output. So in life-science companies, CEOs have a real challenge—they must balance their managerial responsibilities with keeping their understanding of scientific developments up to a level where they can conduct meaningful discussions with R&D. It is also essential for R&D to communicate complex knowledge in a manner that makes sense to CEOs.

Based on the knowledge obtained through our research, CEOs are advised:

- to develop their absorptive capacity by increasing their interactions with R&D scientists at all levels
- to let themselves be trained in the knowledge of R&D
- to train R&D in the business and market
- to develop a firm specific shared vocabulary between him/herself and R&D
- not to interfere with everyday practice of R&D
- to develop the capability of the R&D function to create de-complexified messages of their knowledge
- to use these messages to rally stakeholders behind the idea
- to return the message to R&D to keep it in focus

Doing so, the CEO will generate:

- personal trust in the capabilities of R&D
- generate trust of R&D into the CEO
- create a learning organization that links science to business
- increase the commitment to sharply focused RD projects
- innovative power in his/her organization

7.7 Future research

The thesis leads to additional research questions and questions about research methodologies.

First, a number of interesting research avenues can be envisaged. For example, how can the concept of individual absorptive capacity be better understood? While Pedrosa and Jasmand (2012) have offered a definition of individual absorptive capacity as an organizational member's work-relevant capability to identify new knowledge, assimilate it, apply it, and disseminate it to other organizational members, is there a need to adapt this definition for top management members? This research has shown that identifying new knowledge – the first part in Pedrosa and Jasmand's individual absorptive capacity – is possible if there is a shared frame of reference between the knowledge giver (R&D) and the knowledge acceptor (CEO). How do CEOs then assimilate the new simplified knowledge, apply and disseminate it to other members?

Second, the concept of CEO absorptive capacity also opens interesting research perspectives for trust scholars: what is the impact of CEO absorptive capacity on perceived trust in R&D? What is the relationship between CEO absorptive capacity and his/her trust in complex R&D projects? What is the impact of CEO absorptive capacity on the speed of detection of new opportunities?

Third, the methodologies used to explore the role of the CEOs until now were quantitative based. The arguments raised in the literature (Yadav et al., 2007) for the use of survey based CEO research and CEO research in general is that CEOs are under considerable time pressure which prevents them to engage in qualitative research. However, it was experienced during this research, that the CEOs, in contrast to what is currently posited in the literature, are quite open to qualitative research and the CEOs appreciated and enjoyed the time to discuss their role in innovation. There is, of course, the time pressure put on CEOs which make it difficult for them to make sufficient interview time available and the risk that interview meetings are cancelled immediately prior to the meeting. The direct interaction however proved to be rewarding for both interviewer and CEOs who showed great interest in receiving feedback from this research. It was also found that in order to be able to approach CEOs for qualitative research, it is imperative to find ways of becoming introduced into their networks: the majority of the CEOs in this research agreed to the interview because their colleagues agreed to the study. Finally, in view of the use of absorptive capacity as a potential improved measure compared to CEO demographics, the use of survey based studies could benefit from the use of CEO absorptive capacities, as the instruments to measure these have now become available (Pedrosa and Jasmand, 2012)

Fourth, another potential perspective for research is related to the requirement of transforming complex life science knowledge in simpler terms, not only for reasons of popularization of science, but more importantly to allow the early detection of the potential value or threats (e.g. ethical) of newly developed life science. Realizing that the complexity of science will not decrease but will go hand in hand with its impact on

society, the need for a science that studies the decomplexification of highly complex matters in life sciences may be needed and may involve not only scientists but also linguists.

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Appendix

Appendix A. Procedure for the literature reviews

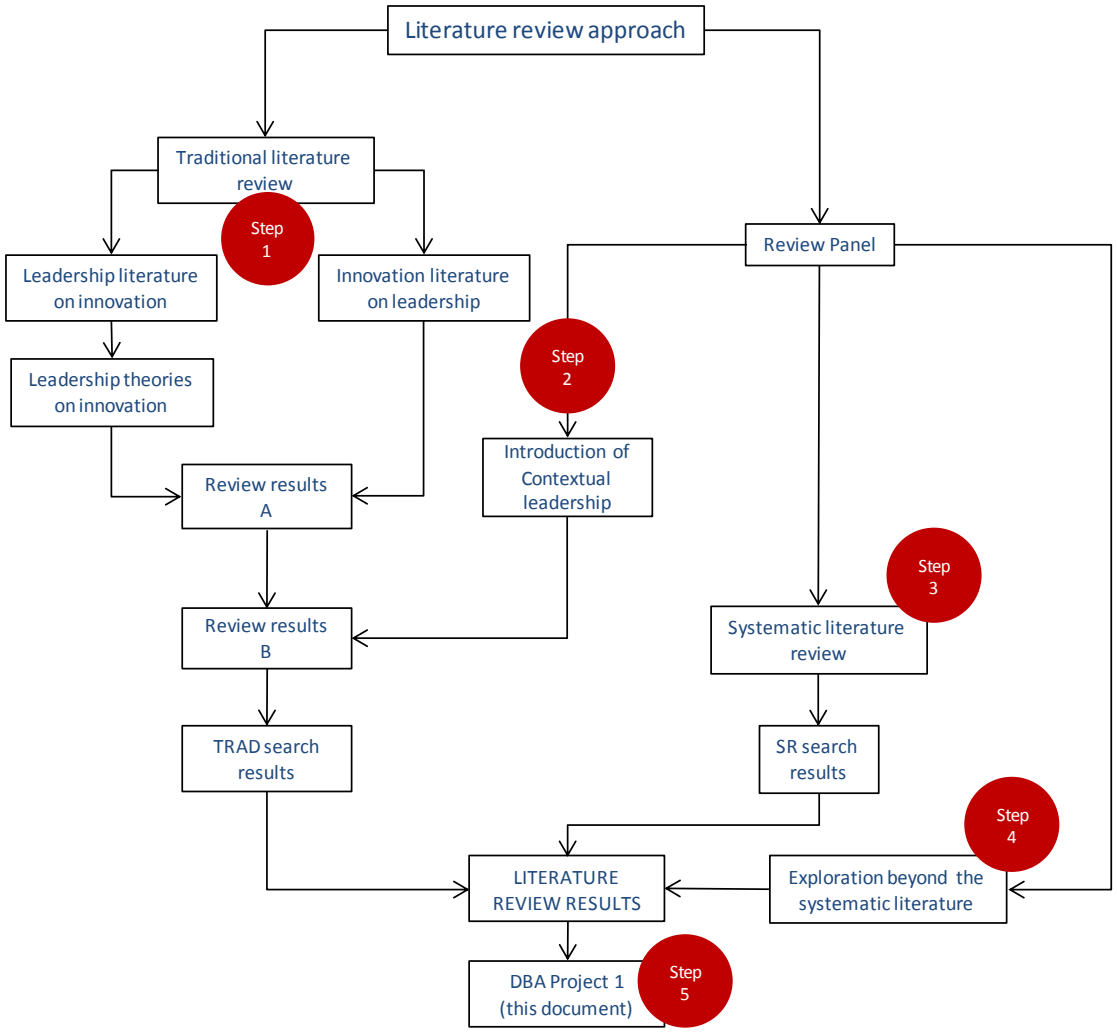
This appendix presents the approach and structure of the literature review. It is based upon

i. a traditional literature review whereby two literature streams – the innovation and the leadership literature – are explored
ii. a systematic review of the literature
iii. an exploration of the literature that goes beyond the systematic review of the literature

The overall approach to search the literature followed five distinct steps.

- **Step 1**. **The traditional review.** The process started with a traditional literature review and the exploration of two literature streams. The leadership literature was reviewed for research data that address innovation and the innovation literature was reviewed for research data that address leadership.
- **Step 2**. **The extended traditional review.** In the traditional review of the literature the conceptual leadership literature was introduced and its relationship with innovation.
- **Step 3**. **The systematic review of the literature.** It was then decided to continue the literature search by engaging into a formal systematic review of the literature. This systematic review of the literature led to a set of papers not previously identified and these were added to the collection of research papers.
- **Step 4**. **Beyond the literature.** It quickly emerged that even a systematic review would have its limitations in this research because a systematic review using specifically selected search terms would miss a key area of leadership literature that present leadership theories and concepts that may be of value in considering the role of CEO and top management in innovation but have not yet been explored. They would not have been identified through a systematic review. It was therefore decided to proceed with a literature search looking for leadership theories and concepts that would be of value in an innovative setting. This allowed the identification of theoretical concepts that were not yet explored before and offered potential better insights and research avenues.
- **Step 5**. **Collecting and reporting the data.** The literature data collected through the traditional literature review, the systematic review and through a literature exploration that went beyond the systematic review resulted in the literature data presented below.

A schematic overview of the general approach is presented in the following diagram (note: in the figure below, reference is still made to 'DBA Project 1' – see bottom of the picture – as this literature review was conducted as part of project 1 of a Doctoral In Business Program).



Traditional review of the literature

The traditional review approached the literature by exploring two literature streams: the leadership literature and the innovation literature. Journals in both literature streams were selected from the Association of Business Schools, Academic Journal Quality Guide[16].

The innovation literature on the leadership of innovation

The following journals were selected based on the ABS-listing of journals in the innovation field:

i. Rank 4: Journal of Product Innovation management
ii. Rank 3: R&D management
iii. Rank 2: Industry and Innovation, Technovation
iv. Rank 1: Creativity and Innovation Management, European Journal of Innovation Management

[16] The Association of Business Schools Academic Journal Quality Guide – Journals Classified by Field and Rank, March 2008, Edt. C. Harvey, H. Morris and A. Kelly – www.the-ABS-org.uk

In addition, the following journals which are not referenced in the ABS-listing of journals in the field of innovation but are available through the ABI/GLOBAL database were also screened:

v. International Journal of Entrepreneurship and Innovation Management
vi. International Journal of Entrepreneurship and Innovation
vii. Innovation
viii. Innovation: Management, Policy and Practice

Journals were screened for articles that contain the term "leader*" in the Citation and Abstract part of the article. The following journals were not used in the search: Stanford Social Innovation Review, Economics of Innovation and New Technology, Construction Innovation.

The leadership literature on leadership of innovation

A number of journals carry the term "leadership" or an equivalent term (eg "leader*") in their journal title. The following journals were selected based on the ABS-listing of journals in the innovation field:

i. Rank 4: Leadership Quarterly
ii. Rank 1: Leadership and Organizational Development Journal
iii. No rank: Journal of Leadership and Organizational Studies

In addition, the Journal of Organizational Behavior (Rank 4) which is classified by ABS in the same field as "Leadership Quarterly", was also included in the search. Some journals identified in the Cranfield Library contain the term "leader(ship)" but were removed from the search exercise, as they refer to leadership in the educational or non-profit sector or specifically address gender issues and leadership[17]. Journals were screened for articles that contained the search term "innovat*" in the citation and abstract part of the article. Journals in the leadership field which are not peer-reviewed or magazines focusing on leadership and act as executive fora were not included in the search[18].

General management literature on leadership of innovation

A search was also conducted in the top-ranking management literature for the search terms "leader*" and "innovat*". A number of high ranking (rank 4) general management journals were included in the search: Academy of Management Journal, Academy of Management Review, Strategic Management Journal and Administrative Science Quarterly. In addition, the ABI/GLOBAL database was searched using the search term "CEO" OR "chief executive officer* AND "innovat*". This search generated articles that specifically address matters related to the CEO and innovation. All papers collected

[17] Advancing Women in Leadership, Leadership in Health Services, Non-profit Management and Leadership, Academy of Educational Leadership, Allied Academies International Conference Academy of Educational Leadership Proceedings

[18] Journals such as: Leadership Excellence, Strategy and Leadership, Leader to leader, Leadership in Action

through the (extended) traditional literature review were introduced into a RefWorks folder.

Systematic review of the literature

The goal of a systematic review is to identify research data in the literature that presents an answer to a specific research question, using a procedure that is both transparent and reproducible (Tranfield et al., 2003). It follows a set of predefined steps as follows:

Identification of the need for a review
Preparation of a proposal for review
Database selection
Conducting the review
Selection of the studies
Quality assessment
Search results
Data extraction

Identification of the need for a review

The need for further research on the role of the CEO in innovation was put forward by Jung et al. (2008) after their research on the impact of transformational leadership styles of CEOs on innovation. This paper was identified after a first unstructured screen of the leadership literature using database search engines. This led to an additional selection of research papers that drew attention to the role of the CEO in innovation and in which different visions were articulated. For example, while some argue that the impact of CEOs is not very relevant (Burgelman et al., 2004; Christensen and Diehl, 1997) and point to the crucial role of middle-level managers in supporting initiatives from operating levels, others have put the CEO back in the seat of innovation (Yadav et al., 2007) or argue that they have an effect on innovation through their support of individuals and teams (Hegarty and Hoffman, 1990; Montoya-Weiss and Calantone, 1994). Still others observed a relationship between CEO demographics and R&D spending (Barker and Mueller, 2002). This first screen of the literature made it clear that it offered inconclusive, diverse and conflicting statements on the role of the CEO and showed considerable debate in the scholarly management literature on the impact of CEOs on innovation (Eggers and Kaplan, 2009; Damanpour and Schneider, 2006; Papadakis and Bourantas, 1998; Elenkov et al., 2005). Therefore, it was decided to conduct a systematic review of the literature in order to obtain a clearer picture of what the literature says on the relationship of the CEO with the R&D function and how this relationship impacts (culture of) innovation. The research question used in this systematic review is:

> "What is the impact of the relationship between the CEO and the R&D function on the culture of innovation?"

Preparation of a proposal for review

This research question was developed to allow a systematic review of the literature to look for research papers that not only addresses the role of the CEO in innovation but also extends the review to areas that would be left uncovered if the research question would be defined too tightly. Therefore the relationship between CEO and R&D is included in the question as it is one of the objectives of our research to explore the R&D's view of the CEO. The concept of culture was also introduced to extend the systematic review outcome to areas beyond the CEO and R&D. The reason for this approach is because the systematic review has its advantages but also limitations. The table below presents the steps taken to mitigate the limitations of the systematic review of the literature. An overly narrow focus of the systematic review of the literature was prevented by addressing two sets of keywords into the research question addressing two different literatures, i.e. the leadership literature and the innovation literature. The risk of omitting relevant studies was reduced by adding a traditional literature review to the systematic review. This approach disclosed areas of the literature that would not have been identified by the systematic review alone and offered a broader view of the relevant literature in which the research is embedded.

Addressing the limitations of the systematic review of the literature		
Limitations of the systematic review	**Steps taken to mitigate these limitations in my approach**	**Examples of the mitigation in my study**
✓ Overly narrow focus	✓ Combine two literature streams	In our research both the leadership and the innovation streams were included through the systematic review question
✓ Omission of relevant studies	✓ Combine the systematic review of the literature with a traditional review of the literature	The systematic review was complemented with a bifocal traditional review of the literature addressing leadership and innovation

The review protocol for the systematic review was developed and is presented in the table below:

Step	**Activity**
1	Identify the databases that will be used
2	Define the search keywords
3	Develop appropriate search strings
4	Introduce the search strings into the databases for a search at the level of TITLE and for a search at the level of ABSTRACT
5	Run the search procedure in the database at the level of TITLE and at the level of ABSTRACT
6	Determine the number of "hits" returned from each database: "T (database)" for hits returned for papers carrying the search string in the TITLE of the paper "A (database)" for hits returned for papers carrying the search string in the ABSTRACT of the paper
7	Read the abstract of all papers identified through the database search irrespective of whether they have been identified through a TITLE or ABSTRACT search
8	Select the papers whose abstracts constitute content that is of value for answering the research question irrespective of whether they have been identified through a TITLE or ABSTRACT search; "paper relevant?"
9	Note the number of papers whose abstracts constitute content that is of value for answering the research question T(database) for TITLE and A(database) for ABSTRACT
10	Archive all selected papers in each database into a specified "RefWorks" folder
11	Remove all duplicates

12	Count the number of papers - the number of papers is "#" - and constitute the final number of papers for further analysis and remove duplicates
13	Reassess all papers and repeat steps 9 to 12
14	Count the number of papers - "#" - and constitute the final number of papers for further analysis
15	Read all papers for their content
16	Apply exclusion/inclusion criteria to each paper
17	Archive included papers "#" in a specified "RefWorks" folder
18	Identify papers cross-referenced in each selected paper
19	Read the referenced paper
20	Apply exclusion/inclusion criteria to each paper
21	Archive referenced papers in the specified "RefWorks" folder
22	Assess the quality level

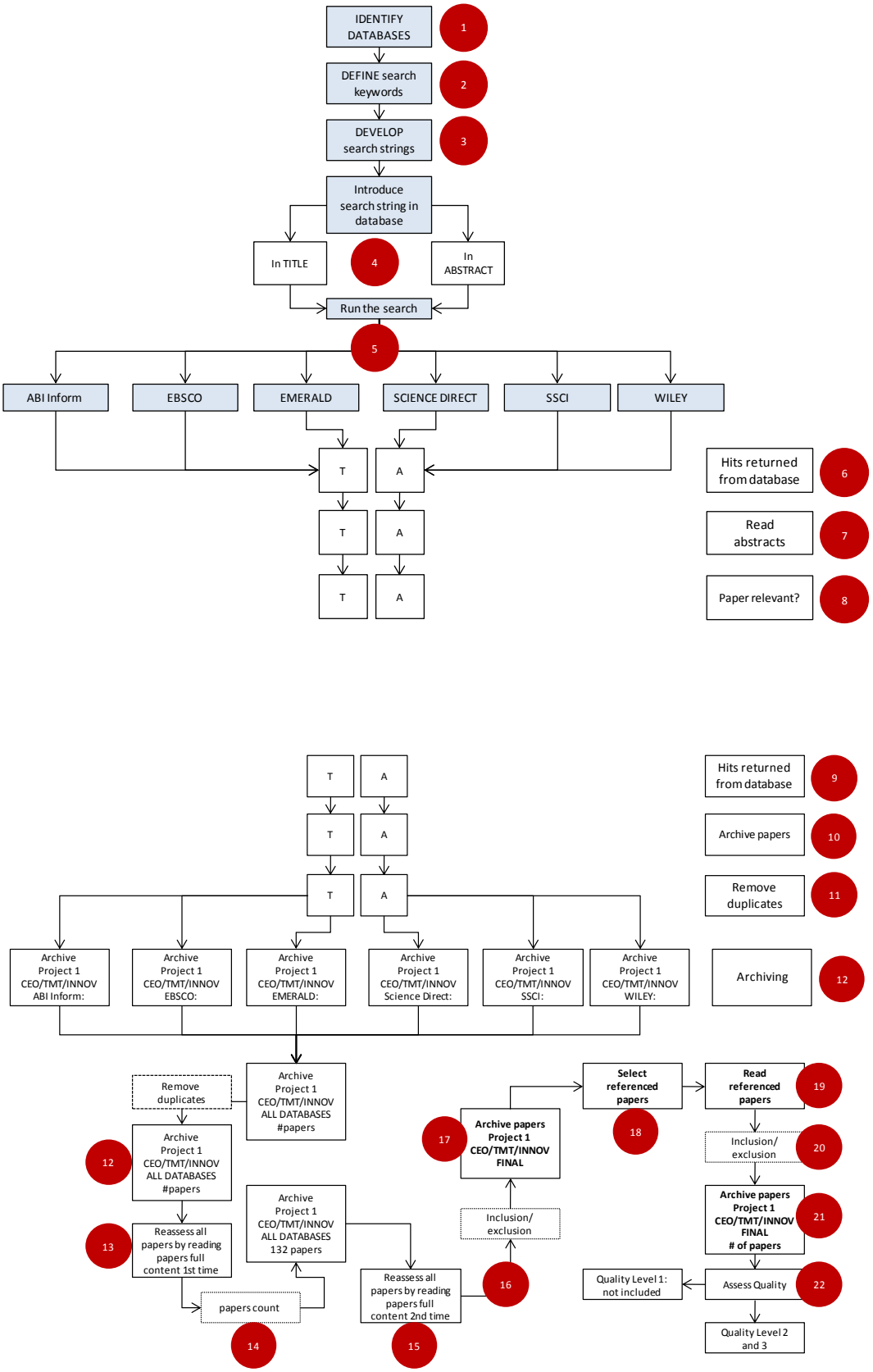
The procedure is presented in two schemes on the following page

Database selection

The databases that were used to search the literature are presented below.

Database	**Description/rationale (from N. Nikitesh, Ph.D. student, Cranfield university)**
ABI/Inform	Specifically, ABI/INFORM Trade & Industry™ is a business and management database in ABI/INFORM. This provides major trade and industry news. It includes in-depth coverage of companies, products, executives, trends, and other topics for more than 1,320 publications, with over 1,150 in full-text. With ABI/INFORM Trade & Industry, users can study and compare specific trades and industries, including telecommunications, computing, transportation, construction, petrochemicals, and many others
EBSCO	Provides full text for more than 8,500 scholarly business journals and other sources, including full text for more than 1,100 peer-reviewed business publications. Coverage includes virtually all subject areas related to business. This database provides full text (PDF) for more than 350 of the top scholarly journals dating as far back as 1922 (EBSCO Information sources)
EMERALD	Emerald is the world's leading publisher of business and management research, with 200 journals and a wide range of serials, series and books in management and related fields. Contains full text of 170,000 peer reviewed papers from many prestigious journals (Emerald Information sources)
SCIENCE DIRECT	Covers over 1700 journals from Elsevier Science and about 60 million abstracts from the field of social science Covers 1700 journals from
SOCIAL SCIENCES CITATION INDEX	Provides journal papers with citation reports and acts as a single route access to all Thomson Reuter's products
WILEY INTER-SCIENCE JOURNALS	Provides access to more than 3 million articles across 1400 journals. These journals cover the full spectrum of science, technology, business, social science and the humanities and include many titles at the forefront of their fields

In order to conduct the systematic review, a review panel was established that consisted of faculty members of Cranfield School of Management and a Cranfield's University library specialist. Before implementing the procedure and conducting the


IDENTIFY DATABASES
1
DEFINE search keywords
2
DEVELOP search strings
3
Introduce search string in database
In TITLE
4
In ABSTRACT
Run the search
5
ABI Inform
EBSCO
EMERALD
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A
Hits returned from database
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Read abstracts
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Paper relevant?
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Hits returned from database
9
Archive papers
10
Remove duplicates
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Archive Project 1 CEO/TMT/INNOV ABI Inform:
Archive Project 1 CEO/TMT/INNOV EBSCO:
Archive Project 1 CEO/TMT/INNOV EMERALD:
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Archive Project 1 CEO/TMT/INNOV SSCI:
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14
Archive Project 1 CEO/TMT/INNOV ALL DATABASES 132 papers
Reassess all papers by reading papers full content 2nd time
15
16
Inclusion/ exclusion
17
Archive papers Project 1 CEO/TMT/INNOV FINAL
Select referenced papers
18
Read referenced papers
19
Inclusion/ exclusion
20
Archive papers Project 1 CEO/TMT/INNOV FINAL # of papers
21
Quality Level 1: not included
Assess Quality
22
Quality Level 2 and 3

systematic review, advice was sought from the systematic review specialist (SR specialist) and in case of doubt the library specialist was consulted. The review panel is presented in the table below.

Expert	Expertise	Affiliation
Prof. K. Goffin	Innovation, Supervisor	Cranfield School of Management
Prof. A. Kakabadse	Leadership, Panel member	Cranfield School of Management
Prof. P. Reinmoller	Strategy, Panel Chair	Cranfield School of Management
Dr. M. Szwejczewski	Innovation and SR specialist	Cranfield School of Management
Ms. H. Woodfield	Library specialist	Cranfield School of Management

Conducting the review

The search terms and search strings are presented in the table below and and are combined into search strings using the Boolean operator "AND" or "OR" and were introduced into the search engines of several literature databases. The search strings were then developed under the assumption that they would generate a number of hits available for review. The keyword "cultur*" was introduced into search string A and B after the first database searches.

Area of investigation	Search Keywords	Target keywords
The role of the CEO in innovation	"CEO" - "chief executive" - "top" – "chief"	chief executive officer, top manager, top management
The role of the top management team in innovation	"Top" – "top management" - "top team" – "TMT" – "CTO" – "CSO"	top management team, top team, TMT, Chief Scientific Officer – Chief Technology Officer
The role of the CEO in innovation	"innovat*"	innovation, innovative, innovators, innovativeness, innovatively, innovative culture, culture of innovation
Other innovation-related terms: R&D, research and development, new product development and technology	"R&D" – "develop*" - "tech*"	new product development, development plans, developability, development projects, development ideas, technology development, technology implementation, technological, R&D, R&D teams, R&D management
Culture of innovation	"cult*"	culture, cultural, cults

Search strings used for the systematic review	
Code	**Search string**
A	"CEO" OR "chief executive" AND "innovat*" OR "R&D" OR "develop*" OR "tech*" (AND "cultur*")
B	"Top" OR "TMT" OR "CTO" OR "CSO" AND "innovat*" OR "R&D" OR "develop*" OR "tech*" (AND "cultur*")

Selection of the studies

Reports which were identified through the database searches were submitted to a selection process according to inclusion/exclusion criteria. The inclusion/exclusion-process is conducted according to the criteria below. From the papers which were selected, other papers were retrieved which were referenced in the first paper and

addressed the role of the CEO. They were also submitted to the inclusion/ exclusion criteria and the quality assessment. There is also a considerable practitioner's literature on the role of the CEO in innovation. This includes numerous interviews of CEOs, book reviews, editorials in magazines and "how to innovate"-articles. These were not included in this review as they do not add to the scientific rigor.

Inclusion and exclusion criteria	
Inclusion criteria	**Justification:**
Academic papers in peer-reviewed scholarly journals, working papers, conference papers, theses and dissertations. The ranking of the journals was not an inclusion/exclusion criterion. Only journals in the English language are included	Journal papers are the primary academic resources on a given subject. Theses and academic working papers may offer the latest thinking on the subject
Papers that specifically address and explore the role of the CEO in innovation and the impact factors on that role	
No restriction on industry or geographical areas	All data on the relation of CEO and innovation irrespective of market or geography may prove valuable
Academic papers that specifically address management research	The topic of interest is in the field of management and therefore other papers that are outside the field of management are of no interest
Exclusion criteria	**Justification:**
Papers that discus the role of the CEO outside of the innovation field	Numerous papers are published on the role of the CEO in firm performance, strategic decision making and other factors but not necessarily on innovation
Papers older than 20 years	We assumed that the number of papers on the role of the CEO in innovation is limited. We employed a timeframe of max. 20 years. Papers published before 1990 were not taken into account. We assumed that older papers, if they are valuable, would be referenced in recent papers.
Anonymous papers	The absence of a reference to an author makes it difficult to address the argument
Papers or documents that present a personal vision on the topic such as editorials, considerations, opinions, advisory statements, consulting advice, 'how to innovate'-articles, generic and/or consultant 'recipes'	These documents do not add to the academic rigor that is required for this systematic review
Interview of CEOs	Although potentially interesting (and numerous), these interviews were not withheld because they offer a quite 'glossy' view on the CEO's role in innovation. They are also not scientifically valid interviews conducted as part of a qualitative study
Papers that do not specifically refer to the role of a CEO in innovation	There are several studies that study the role of the CEO on corporate culture and firm performance. When these studies do not include a reference to innovation as a

	parameter of firm performance, they were not included
Papers, cases or books that refer to the subject from a general point of view and do not add to the knowledge of the role of the CEO in innovation but merely represent an author's personal experience	There are numerous cases and books on the role of the CEO and upper management in innovation but these documents do not add to the academic rigor that is required for this systematic review
Scholarly papers addressing innovation with a technically applied focus in the areas of biology, physics or chemistry and disciplines derived thereof	The topic of interest is in the field of management and papers that are inside the field of innovation but only address technical issues are not of interest

Quality assessment

The papers were 'qualified' using a scoring system by which 7 quality parameters were scored between 1 and 3. The 7 quality parameters were: literature review (A), theoretical background (B), methodology and methods (C), data analysis and results (D), generalizability (E), contribution to knowledge (F), limitations and potential for future research (G) as presented in the table below.

Parameter A to G	**Quality Scoring**		
	Score 1	**Score 2**	**Score 3**
Literature review (A)	Poorly covered literature landscape	Basic coverage of literature landscape	Excellent coverage of literature landscape
Theoretical background (B)	Report does not demonstrate awareness of existing theories and current theoretical developments	Reasonably good review of theoretical background	Excellent review of theoretical background and demonstrates a clear link of theory with the research area and hypothesis; reviews and summarizes studies previously carried out
Methodology & methods (C)	Rationale for the use of a methodology not stated. Difficult to find link between methods used and the research objectives	Reasonably good research design with acceptable methodology and appropriate methods used to complete the study	Clear link of the methodology used to the research question and theoretical foundation. Methods used are clearly in line with what is being achieved
Data analysis and results (D)	Poor data sources, no clear explanation of the sample used. Results are not explained very clearly in light of research objectives	Reasonably good data sources; data sample is justifiable; results are relevant and in line with the objectives of the research	Excellent data sources data sample is appropriately chosen; analysis results are in line with the objectives of the research and there is a description of how these are similar or dissimilar to papers from other researchers/sources
Generalizability (E)	Single cases where investigation involved a particular type of innovation	Countries or industries of similar characteristics	High level of generalizability; any country or any industry or any product

Contribution to knowledge (F)	Does not make any important contribution; contribution not mentioned in the paper	Builds upon existing theory and the contribution is appropriately positioned in the existing body of literature	Contributes further to developing existing knowledge; develops the technique through which the research area was explained
Limitations and potential for future research (G)	Limitations not stated although it lacks theoretical backing, methodological rigor and have used poor data	Limitations stated but do not explain its relevance to understand the results of the study; future research areas not stated	Limitation of the study explicitly stated and clearly understood; provides areas for further research that can enhance understanding

For example, for a given quality parameter such as literature review, a score was assigned 1, 2 or 3, indicating a "poorly covered literature landscape" (a score of 1), a "basic coverage of the literature (score 2) or an "excellent coverage of the literature landscape" (score 3) respectively. Each quality parameter, A to G, was assessed using this scoring system. For all quality parameters combined, the total score (TS) lies between 7 (7 x score 1) and 21 (7 x score 3). The total score was then used to categorize the papers into three classes along three different levels of scores: TS < 10 for low quality, 10<TS<17 for medium quality and TS>17 for high quality. The final scores for each paper are collected in table on the next page. For example, Ettlie's paper (Ettlie J.E. , 1990) was given a score of 1 to each quality parameter leading to a total score of 7 while Bang et al.'s paper (Bang et al., 2006) received a slightly higher score of 8, because the literature review was not considered " poor" but "basic" (a score of 2). On the other hand, the Papadakis and Bourantas' paper (Papadakis and Bourantas, 1998) received a score of 13 because the literature review was high quality and could easily be compared with the literature reviews of the top papers while the "generalizability" was only poor as their study is limited to Greek industrial companies without any reference to size or industrial innovation capabilities. The table below lists the papers with increasing quality (from 7 to 21) and identifies the papers which were also identified through a traditional review of the literature ("TR" in the table and indicated by means of a red square). The quality appraisal distribution for the papers identified is as follows:

Quality appraisal of the papers retrieved from the systematic review	
Low 1	**Number of papers: 3**
	Al-Qirim, N. (2007), "The adoption of e Commerce communications and applications technologies in small businesses in New Zealand", *Electronic Commerce Research & Applications,* vol. 6, no. 4, pp. 462-473. Bang, N. J., Kyeong, S. H. and Myung, J. L. (2006), "Determining factors for the adoption of e-business: the case of SMEs in Korea", *Applied Economics,* vol. 38, no. 16, pp. 1905-1916. Ettlie, J. E. (1990), "What makes a manufacturing firm innovative?", *Executive,* vol. 4, no. 4, pp. 7-20.

Quality scoring

	A	B	C	D	E	F	G	Total	Year	TR
Level 1 papers: TS < 10										
Ettlie, J. E. (1990)	1	1	1	1	1	1	1	7	1990	
Bang, N. J., Kyeong, S. H. and Myung, J. L. (2006)	2	1	1	1	1	1	1	8	2006	
Al-Qirim, N. (2007)	1	1	1	1	2	1	2	9	2007	
Level 2 papers: 10 </= TS </= 15										
Scherer, F. M. and Huh, K. (1992)	1	2	1	2	1	2	1	10	1992	
Schoenecker, T. (1993)	1	1	1	1	2	2	2	10	1993	
Dickson, P., Schneier, W., Lawrence, P. and Hytry, R. (1995)	1	1	1	2	2	2	1	10	1995	
Kickul, J. and Gundry, L. (2001)	1	1	2	1	1	2	2	10	2001	
Datta, D. K., Guthrie, J. P. and Rajagopalan, N. (2002)	1	2	1	1	1	2	2	10	2002	
Laforet, S. and Tann, J. (2006)	2	1	1	1	2	2	1	10	2006	
Simsek, Z. (2007)	1	1	2	2	1	2	1	10	2007	
Bantel, K.A. and Jackson, S.E. (1989)	2	2	1	2	1	1	2	11	1989	
Datta, D. K. and Guthrie, J. P. (1994)	1	1	2	2	1	2	2	11	1994	
Calantone, R. J., Vickery, S. K. and Dröge, C. (1995)	2	1	1	2	2	2	1	11	1995	
Green, S. G. (1995)	1	2	2	2	1	2	1	11	1995	
Kitchell, S. (1997)	2	2	1	1	2	2	1	11	1997	
Young, G. J., Charns, M. P. and Shortell, S. M. (2001)	1	3	2	2	1	1	1	11	2001	
Wu, W., Chiang, C. and Jiang, J. (2002)	2	1	1	2	1	2	2	11	2002	
Carbonell, P. and Rodríguez-Escudero, A. (2009)	2	2	1	2	1	2	1	11	2009	
Lin, C., Lin, P., Song, F. M. and Li, C. In Press, Accepted Manuscript	1	2	2	2	1	2	1	11	2010	
Miller, D. and Toulouse, J. (1986a)	1	1	2	2	2	2	2	12	1986	
Miller, D. and Toulouse, J. (1986b)	1	1	2	2	2	2	2	12	1986	
Thong, J. Y. L. and Yap, C. S. (1995)	2	1	2	2	2	2	1	12	1995	
Tyler, B. B. and Steensma, H. K. S. (1998)	1	2	2	2	1	2	2	12	1998	
Daellenbach, U. S., McCarthy, A. M. and Schoenecker, T. S. (1999)	2	2	1	2	1	3	1	12	1999	
Deeds, D. L., DeCarolis, D. and Coombs, J. (2000)	2	2	2	2	1	2	1	12	2000	
Damanpour, F. and Schneider, M. (2006)	2	2	1	2	1	3	1	12	2006	
Dechow, P. M. and Sloan, R. G. (1991)	1	1	2	2	3	2	2	13	1991	
Lefebvre, L. A., Mason, R. and Lefebvre, E. (1997)	2	2	2	2	2	1	2	13	1997	
Papadakis, V. and Bourantas, D. (1998)	3	2	2	2	1	2	1	13	1998	
Barker, V. L.,III and Mueller, G. C. (2002)	2	2	2	2	1	3	1	13	2002	
Lynskey, M. J. (2004)	3	2	3	2	1	1	1	13	2004	
Yadav, M. S., Prabhu, J. C. and Chandy, R. K. (2007)	2	2	2	2	1	3	1	13	2007	
Berson, Y., Oreg, S. and Dvir, T. (2008)	2	2	2	1	2	2	2	13	2008	
Lefebvre, E. and Lefebvre, L. A. (1992)	1	1	2	2	2	3	3	14	1992	
Beal, R.M. and Yasai-Ardekani, M., (2000)	2	2	2	2	2	2	2	14	2000	
Elenkov, D. S., Judge, W. and Wright, P. (2005)	1	3	2	2	3	2	1	14	2005	
Elenkov, D. S. and Manev, I. M. (2005)	2	2	2	2	3	2	2	15	2005	
Level 3: TS > 15 (maximum score is 21)										
Swink, M. (2000)	2	2	3	3	2	2	2	16	2000	
Jung, D. I., Chow, C. and Wu, A. (2003),	2	3	3	2	2	3	2	17	2003	
Jung, D. (., Wu, A. and Chow, C. W. (2008),	2	3	3	3	2	3	2	18	2008	
Wu, S., Levitas, E. and Priem, R. I. (2005)	3	2	3	2	3	3	3	19	2005	
Ling, Y., Simsek, Z., Lubatkin, M. H. and Veiga, J. F. (2008)	3	3	3	3	2	3	2	19	2008	
DeTienne, D. R. and Koberg, C. S. (2002)	3	3	3	3	3	3	3	21	2002	
Eggers, J. and Kaplan, S. (2009)	3	3	3	3	3	3	3	21	2009	
Makri, M. and Scandura, T. A. (2010)									2010	

Legend:

TS: Total Score ; A: Literature review; B: Theoretical background; C: Methodology and methods; D. Data analysis and results; E. Generalizability; F. Contribution to knowledge; G. Limitations for potential future research; Scores: 1: low quality; 2: medium quality; 3 : high quality; TR: these papers were also identified through the traditional review of the literature; Year: year of publication

Medium 2	Number of papers: 34
	Barker, V. L.,III and Mueller, G. C. (2002), "CEO characteristics and firm R&D spending", *Management Science,* vol. 48, no. 6, pp. 782. Beal, R.M. and Yasai-Ardekani, M., (2000), "*Performance implications of aligning CEO functional experiences with competitive strategies*", Journal of Management Vol. 26, no.4, p.733. Berson, Y., Oreg, S. and Dvir, T. (2008), "CEO values, organizational culture and firm outcomes", *Journal of Organizational Behavior,* vol. 29, no. 5, pp. 615-633. Calantone, R. J., Vickery, S. K. and Dröge, C. (1995), "Business Performance and Strategic New Product Development Activities: An Empirical Investigation", *Journal of Product Innovation Management,* vol. 12, no. 3, pp. 214-223. Carbonell, P. and Rodríguez-Escudero, A. (2009), "Relationships among team's organizational context, innovation speed, and technological uncertainty: An empirical analysis", *Journal of Engineering and Technology Management,* vol. 26, no. 1/2, pp. 28. Daellenbach, U. S., McCarthy, A. M. and Schoenecker, T. S. (1999), "Commitment to innovation: The impact of top management team characteristics", *R & D Management,* vol. 29, no. 3, pp. 199. Damanpour, F. and Schneider, M. (2006), "Phases of the Adoption of Innovation in Organizations: Effects of Environment, Organization and Top Managers1", *British Journal of Management,* vol. 17, no. 3, pp. 215. Datta, D. K. and Guthrie, J. P. (1994), "Executive Succession: Organizational Antecedents of Ceo Characteristics", *Strategic Management Journal,* vol. 15, no. 7, pp.569-577. Datta, D. K., Guthrie, J. P. and Rajagopalan, N. (2002), "Different industries, different CEOs? A study of CEO career specialization", *Human Resource Planning,* vol. 25, no. 2, pp. 14. Dechow, P. M. and Sloan, R. G. (1991), "Executive incentives and the horizon problem", *Journal of Accounting & Economics,* vol. 14, no. 1, pp. 51-89. Deeds, D. L., DeCarolis, D. and Coombs, J. (2000), "Dynamic capabilities and new product development in high technology ventures: An empirical analysis of new biotechnology firms", *Journal of Business Venturing,* vol. 15, no. 3, pp. 211. Dickson, P., Schneier, W., Lawrence, P. and Hytry, R. (1995), "Managing design in small high-growth companies", *The Journal of Product Innovation Management,* vol. 12, no. 5, pp. 406. Elenkov, D. S., Judge, W. and Wright, P. (2005), "Strategic leadership and executive innovation influence: an international multi-cluster comparative study", *Strategic Management Journal,* vol. 26, no. 7, pp. 665. Elenkov, D. S. and Manev, I. M. (2005), "Top Management Leadership and Influence on Innovation: The Role of Sociocultural Context", *Journal of Management,* vol.31, no. 3, pp. 381.

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Kickul, J. and Gundry, L. (2001), "Breaking through boundaries for organizational innovation: New managerial roles and practices in e-commerce firms", *Journal of Management,* vol. 27, no. 3, pp. 347.

Kitchell, S. (1997), "CEO characteristics and technological innovativeness: A Canadian perspective", *Revue Canadienne des Sciences de l'Administration,* vol. 14,no. 2, pp. 111.

Laforet, S. and Tann, J. (2006), "Innovative characteristics of small manufacturing firms", *Journal of Small Business and Enterprise Development,* vol. 13, no. 3, pp.363.

Lefebvre, E. and Lefebvre, L. A. (1992), "Firm Innovativeness and CEO Characteristics in Small Manufacturing Firms", *Journal of Engineering and Technology Management,* vol. 9, no. 3,4, pp. 243.

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Lin, C., Lin, P., Song, F. M. and Li, C. "Managerial Incentives, CEO Characteristics and Corporate Innovation in China's Private Sector", *Journal of Comparative Economics,* vol. In Press, Accepted Manuscript.

Ling, Y., Simsek, Z., Lubatkin, M. H. and Veiga, J. F. (2008), "The impact of transformational CEOs on the performance of small- to medium-sized firms: Does organizational context matter?", *Journal of Applied Psychology,* vol. 93, no. 4, pp. 923.

Lynskey, M. J. (2004), "Determinants of Innovative Activity in Japanese Technology-based Start-up Firms", *International Small Business Journal,* vol. 22, no. 2, pp.159.

Miller, D. and Toulouse, J. (1986a), "Chief Executive Personality and Corporate Strategy and Structure in Small Firms", *Management Science* vol.32, no. 11, pp. 1389.

Miller, D. and Toulouse, J. (1986b), "Strategy, Structure, CEO Personality and Performance in Small Firms", *American Journal of Small Business,* vol. 10, no. 3, pp.47.

Papadakis, V. and Bourantas, D. (1998), "The chief executive officer as corporate champion of technological innovation: An empirical investigation", *Technology Analysis & Strategic Management,* vol. 10, no. 1, pp. 89.

Scherer, F. M. and Huh, K. (1992), "Top Managers' Education and R&D Investment", *Research Policy,* vol. 21, no. 6, pp. 507.

Simsek, Z. (2007), "CEO tenure and organizational performance: an intervening model", *Strategic Management Journal,* vol. 28, no. 6, pp. 653-662.

Thong, J. Y. L. and Yap, C. S. (1995), "CEO characteristics, organizational characteristics and information technology adoption in small businesses", *Omega,* vol. 23,no. 4, pp. 429-442.

	Tyler, B. B. and Steensma, H. K. (1998), "The Effects of Executives' Experiences and Perceptions on their Assessment of Potential Technological Alliances", *Strategic Management Journal (1986-1998),* vol. 19, no. 10, pp. 939. Wu, W., Chiang, C. and Jiang, J. (2002) "Interrelationships between TMT management styles and organizational innovation", Industrial management, vol. 102, no. ¾, pp. 171. Yadav, M. S., Prabhu, J. C. and Chandy, R. K. (2007), "Managing the Future: CEO Attention and Innovation Outcomes", *Journal of Marketing,* vol. 71, no. 4, pp. 84. Young, G. J., Charns, M. P. and Shortell, S. M. (2001), "Top manager and network effects on the adoption of innovative management practices: A study of TQM in a public hospital system", *Strategic Management Journal,* vol. 22, no. 10, pp. 935.
High 3	**Number of papers: 8**
	DeTienne, D. R. and Koberg, C. S. (2002), "The impact of environmental and organizational factors on discontinuous innovation within high-technology industries", *IEEE Transactions on Engineering Management,* vol. 49, no. 4, pp. 352. Eggers, J. and Kaplan, S. (2009), "Cognition and Renewal: Comparing CEO and Organizational Effects on Incumbent Adaptation to Technical Change", *Organization Science,* vol. 20, no. 2, pp. 461. Jung, D. I., Chow, C. and Wu, A. (2003), "The role of transformational leadership in enhancing organizational innovation: Hypotheses and some preliminaryfindings", *Leadership Quarterly,* vol. 14, no. 4,5, pp. 525. Jung, D. (., Wu, A. and Chow, C. W. (2008), "Towards understanding the direct and indirect effects of CEOs' transformational leadership on firm innovation", *Leadership Quarterly,* vol. 19, no. 5, pp. 582. LING, Y., SIMSEK, Z., LUBATKIN, M. H. and VEIGA, J. F. (2008), "Transformational Leadership's Role in Promoting Corporate Entrepreneurship: Examining the Ceo-Tmt Interface", *Academy of Management Journal,* vol. 51, no. 3, pp. 557-576. Makri, M. and Scandura, T. A. (2010), "Exploring the effects of creative CEO leadership on innovation in high-technology firms", *The Leadership Quarterly,* vol. 21,no. 1, pp. 75-88. Swink, M. (2000), "Technological innovativeness as a moderator of new product design integration and top management support", *The Journal of Product Innovation Management,* vol. 17, no. 3, pp. 208. Wu, S., Levitas, E. and Priem, R. I. (2005), "Ceo Tenure and Company Invention Under Differing Levels of Technological Dynamism", *Academy of Management Journal,* vol. 48, no. 5, pp. 859.

Search results

The table below collects the number of papers ("hits") returned after introduction of the search strings in the databases.

i. The first column includes the search strings, starting with search strings A and B and an additional set of 5 search strings developed during the search process.
i. The second column includes the number of hits returned by the database after introduction of reviewed) papers that carry the search terms in the paper's titles.
ii. The third column includes the number of hits returned by the database after introduction of the search string in the database search engine which was asked to identify scholarly (peer reviewed) papers that carry the search terms in the paper's abstracts.
iii. The data representing the number of hits in the second and third column contain 2 numbers; the top number is the number of hits returned by the database search engine and the bottom number is the number of papers obtained after application of the inclusion/exclusion criteria

As an example, inserting search string 1 ["CEO" AND "innovat*"] in the ABI/Inform database returned 16 papers that carry these two terms in the title. Of these 16 papers, 10 were withheld after application of the inclusion/exclusion criteria. When the originally developed search string ["CEO" OR "chief executive" AND "innovat*" OR "R&D" OR "develop*" OR "tech*"] was introduced in the database, it returned 93 papers combining these terms in the title, and 32 were retained for further evaluation. Papers which passed the inclusion/criteria selection, were exported to a RefWorks archive folder identified as "Project 1 CEO/TMT/INNOV ABI/Inform".

The originally developed search strings A ["CEO" OR "chief executive" AND "innovat*" OR "R&D" OR "develop*" OR "tech*"] and B ["Top" OR "TMT" OR "CTO" OR "CSO" AND "innovat*" OR "R&D" OR "develop*"], returned a high number of papers that carry a search term or a combination of search terms in the abstract section of the paper: 3282 and 8239 respectively. As this number is too large for a review within an acceptable time period, we did not evaluate these abstracts, and NE (Not Evaluated) is added in the table. In order to generate an acceptable number of papers carrying the search terms in the abstract section we simplified search strings A and B by removing

SEARCH RESULTS		
Search string:	**Hits in TITLE**	**Hits in CITATION & ABSTRACT**
ABI/INFORM (Proquest) - number of scholarly journals		
Search string A: "CEO" OR "chief executive" AND "innovat*" OR "R&D" OR "develop*" OR "tech*"	93 32	3282 NE
Search string B : "Top" OR "TMT" OR "CTO" OR "CSO" AND "innovat*" OR "R&D" OR "develop*"	53 29	8239 NE
Additional set of search strings developed during the search process:		
Search string 1. "CEO" AND "innovat*"	16 10	386 74
Search string 2. "Top management team" OR "TMT" AND "innovat*"	13 13	146 57
Search string 3. "CEO" AND "R&D"	7	124

	7	33
Search string 4. “CEO” and “CTO” OR “CSO”	1 1	17 5
Search string 5. “CEO” OR “chief executive” AND “innovat*” OR “R&D” OR “develop*” OR “tech*” – DISSERTATIONS (titles and abstracts)	7 4	230 28
Number of references returned through search	189	903
Number of papers after application of inclusion/exclusion criteria	96	197
Total number of papers in RefWorks (folder “ Project 1 CEO/TMT/INNOV ABI/Inform) after duplicate check	225	
EBSCO (Business Source Complete) - number of scholarly journals		
Search string A: “CEO” OR “chief executive” AND “innovat*” OR “R&D” OR “develop*” OR “tech*”	>5k NE	>50k NE
Search string B : “Top” OR “TMT” OR “CTO” OR “CSO” AND “innovat*” OR “R&D” OR “develop*”	>100k NE	>500k NE
Additional set of search strings developed during the search process:		
“CEO” AND “innovat*”	18 9	225 50
“Top management team” OR “TMT” AND “innovat*”	219 61	516 134
“CEO” AND “R&D”	5 5	53 22
“CEO” and “CTO” OR “CSO”	28 0	126 3
Number of references returned through search	270	920
Number of papers after application of inclusion/exclusion criteria	75	208
Total number of papers in RefWorks (folder “Project 1 CEO/TMT/INNOV BESCO”) after duplicate check	167	
EMERALD DATABASE number of scholarly journals		
“CEO” AND “innovat*”	0	185 20
“top management team” AND “innovat*”	0	81 16
Number of references returned through search	0	266
Number of papers after application of inclusion/exclusion criteria	0	21
Total number of papers in RefWorks (folder “Project 1 CEO/TMT/INNOV EMERALD”) after duplicate check	21	
SCIENCE DIRECT DATABASE		
“CEO” AND “innovat*”	7 4	35 17
“top management team ” AND “innovat*”	4 4	18 12
Number of references returned through search	11	53
Number of papers after application of inclusion/exclusion criteria	8	29
Total number of papers in RefWorks (folder “Project 1 CEO/TMT/INNOV SCIENCE DIRECT”) after duplicate check	19	
SSCI DATABASE		
“CEO” AND “innovat*”	21 8	285 57
“top management team” AND “innovat*”	9 9	141 69
Number of references returned through search	30	426
Number of papers after application of inclusion/exclusion criteria	17	126

Total number of papers in folder "Project 1 CEO/TMT/INNOV SSCI" after duplicate check19	109	
WILEY INTERSCIENCE JOURNALS DATABASE		
"CEO" AND "innovat*"	5 2	353 25
"top management team" AND "innovate*"	5 4	373 26
Number of references returned through search	10	726
Number of papers after application of inclusion/exclusion criteria	4	76
Total number of papers in folder "Project 1 CEO/TMT/INNOV WILEY" after duplicate check	73	

the Boolean operator "OR" and the terms ["develop*"] and ["tech*"], which generated a search result that is too broad because of the use of "develop*" in contexts such as "development of a test method" or "development of a new market" and the use of "tech*" in contexts such as "technological markets", "technologists", "technical know how", "technicians" etc.. When the search term "tech* was removed from search string A, the search still returned 2503 hits. When the search term 'tech*" and "develop*" were removed, the number of hits was 660. The search was continued using search strings 1 to 5, because they showed more discriminative power while keeping the original keywords such as "CEO", "CTO", "CSO", "innovat*" and "R&D" in the search strings, specifically addressing our topic of the role of the CEO in science-based innovation. As the ABI/Inform database allows for a search of dissertations we introduced search string 5 into the database search engine to look for relevant dissertations (10th row). After having introduced all search strings into the database for a search at the level of title and at the level of abstract, and after having applied the inclusion and exclusion criteria, a number of 96 papers carrying the search terms in the title and 197 papers carrying the search terms in the abstract were identified . These papers were transferred into the RefWorks' "Project 1 CEO/TMT/INNOV ABI/Inform"-archive and screened for duplicates. Applying this duplication test on the data, resulted in a collection of 225 papers. The same procedure was introduced in the EBSCO (Business Source Complete) database and resulted in 167 relevant papers. The relevant papers obtained from the EBSCO search was collected in a RefWorks archive entitled "Project 1 CEO/TMT/INNOV EBSCO". In addition to the ABI/Inform and the EBSCO research, three additional databases were searched for relevant papers: EMERALD, SCIENCE-DIRECT, Social Sciences Citation Index and WILEY Interscience Journals.

Finally, the papers collected in RefWorks archives "Project 1 CEO/TMT/INNOV ABI/Inform", "Project 1 CEO/TMT/INNOV EBSCO", "Project 1 CEM/TMT/INNOV EMERALD" and "Project 1 CEO/TMT/INNOV SCIENCE DIRECT" were transferred in a new RefWorks archive entitled "Project 1 CEO/INNOV All databases" and checked for duplicates. The list of papers obtained by searching the SSCI and WILEY databases were collected in archives as a pdf file and identified as "Project 1 CEO/TMT/INNOV SSCI" and a folder "Project 1 CEO/TMT/INNOV. These lists were then compared with the list of

[19] The searches in SCIENCE DIRECT and WILEY could not be directly transferred to Ref Works and were introduced in a pdf-file and stored separately

papers available in “Project 1 CEO/INNOV All databases” and checked manually for papers that were either duplicates or which were not “catched” previously through the ABI/Inform-, EBSCO-, EMERALD- and SCIENCE DIRECT-searches. This resulted in a collection of 405 papers. This collection of 405 papers was then tested for duplicates. This resulted in a collection of 360 papers. Each abstract of these 360 papers was then reviewed one by one for their relevance for our review. A collection of 132 scholarly (peer reviewed) papers were retained for further scrutiny and were then transferred in a final archive in RefWorks entitled: “Project 1 CEO/INNOV Final List”. Subsequently, each of the 132 research papers were read and those that actually discussed the role of the CEO in innovation and factors that impact on this role such as CEO characteristics (demography and personality characteristics), context, the top management team, compensation, perception, attitude towards innovation etc. etc. were retained for data extraction and further study. This resulted in a final list of 45 relevant papers. We have also entered search strings A and B with the inclusion of the keyword ”cul*” in order to find papers that specifically study the role of a CEO in an R&D setting and the impact of that on culture of innovation in R&D settings. The output of this search was limited and no valuable papers were retained.

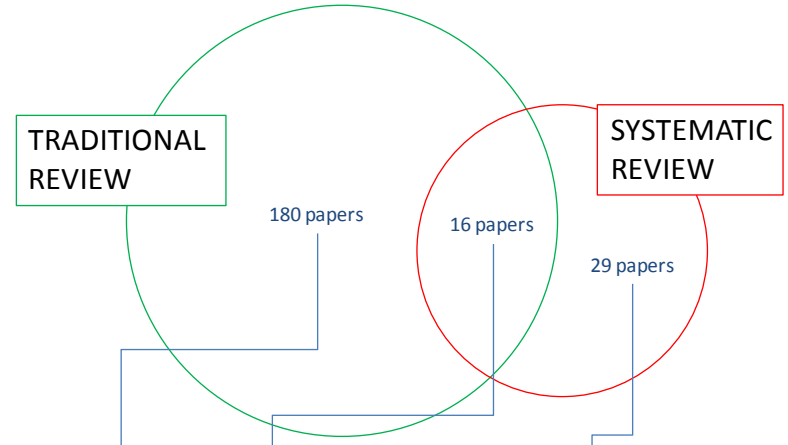
Data extraction

The papers collected through the traditional and the systematic review are not be discussed ‘on their own’ as if they were disconnected from the rest of the literature, instead, they were rearranged according to specific topics which constitute the backbone of this literature review. This data categorization was conducted after a thorough analysis of each paper. This allowed the paper to be assigned to a category of research addressing a topic of the role of the CEO in innovation (see Chapter 2).

Comparing and separating the traditional review vs the systematic review

The figure below shows that 209 papers were retrieved from both the traditional literature review (196 papers) and the systematic literature review (45 papers). The systematic literature review allowed the identification of 16 papers which were also identified through a traditional review of the literature. There is no difference in the quality distribution of the papers which were identified both by traditional and systematic review and the papers identified only by the systematic review of the literature. In both cases the percentage of papers in the medium quality group is 82%, while the percentage of high quality papers identified through the traditional and the systematic review is 18 and 17% respectively. When studying the literature references of the top quality papers retrieved by the traditional review of the literature (Jung et al. 2003; Jung et al. 2008 and Makri and Scandura, 2010), there is no reference to the papers which were additionally retrieved as a result of the systematic review (Swink, 2000; Detienne et al., 2002; Wu et al., 2005; Ling et al., 2008; Eggers and Kaplan, 2009). This illustrates the efficiency of the systematical review in exploring the literature more deeply and more refined then a traditional review. The traditional literature review however offers a more expanded view of the literature in that it offers the environment in which the data retrieved from the systematical review are to be positioned. The traditional review opened a larger field of data that were helpful in putting the granular

data of the systematic review into perspective. Also, the traditional review of the literature generated papers that approached the problem from a fresh perspective such as the CEO-adviser model (Arendt et al. ,2005) and the



QUALITY LEVEL		
High Q	Medium Q	Low Q
3	13	0
Q3/TOTAL = 18%		
Q2/TOTAL = 82%		
Q1/TOTAL = 0%		

QUALITY LEVEL		
High Q	Medium Q	Low Q
5	21	3
Q3/TOTAL = 17%		
Q2/TOTAL = 82%		
Q1/TOTAL = 1%		

close and distant leadership concept (Waldman and Yammarino, 1999). These papers can only be found in the literature environment of the topic at hand but it is these papers that enriched the thinking about the role of the CEO in innovation. In summary, while the systematic review offered a deep knowledge of a very specific topic and extended the knowledge beyond the raw traditional reviews of the literature, the latter offered a mental map of the overall literature

Beyond the systematic review of the literature

Following the argument that it would be worthwhile to conduct a search for leadership theories which have not yet been used in an innovative setting, another review of the literature was undertaken to look for leadership theories which have not yet been used in innovative settings. Three documents were used as a source of reference on leadership theory:

i. Leadership: Current Theories, Research, and Future Directions (Avolio et al., 2009)
ii. Leadership theory and Practice (Northouse, 2010)
iii. Essence of leadership (Kakabadse and Kakabadse, 1999)

These sources were used as reference documents to inquire which of the theories presented could be of value to understand the role of the CEO in an innovative setting. The goal of the section is not to offer a comprehensive overview and analysis of untested theories and models, but instead to explore alternatives in the research into the role of the CEO in innovation, without trying to achieve completeness either through scope or through depth.

Appendix B. Upper echelon theory – Overview of the literature data

The upper echelon perspective has led to a wide variety of research that was conducted in an attempt to link CEO characteristics to different measures of innovation.

Education and innovation

CEOs have different functional and educational backgrounds (Gupta and Govindarajan, 1984) and backgrounds in science or engineering are associated with progress, invention, and improvement (Wiersema and Bird, 1996). It is therefore reasonable to believe that CEOs with science and engineering backgrounds have more potential to foster innovation than CEOs with other educational histories. The literature links the attained educational level 'cognitive ability, capacity for information processing, tolerance for ambiguity with propensity or receptivity for innovation' (Bantel and Jackson, 1989; Hambrick and Mason, 1984; Datta and Guthrie, 1994a). It can thus be hypothesised that the higher the top management's educational level the more it will foster innovation. For example, in a study of the banking industry, Bantel and Jackson (Bantel and Jackson, 1989) found that more innovative banks are led by top managers with relatively higher levels of education. In addition, top managers' education levels have been linked empirically with the need to change the status quo and to implement strategic change (Wiersema and Bantel, 1992). This is also true for the CEO's team; Bantel and Jackson argue that more innovative firms tend to have more highly educated management teams and Pfeffer posits that R&D companies are best served by individuals with advanced training and education (Pfeffer, 1985). Several researchers have looked into the impact of prior education of CEOs on measures of innovation as will be reported in the following section.

CEO education and R&D spending

R&D spending is considered a measure of innovative effort and has therefore been used frequently to assess the impact of CEOs (Adams et al., 2006). Hayes and Abernathy (Hayes and Abernathy, 1980) attributed the 'short-sighted' investment policies in the 1980's in the USA and the declining growth of the US economy, to the increasing number of specialists in law and finance at the top levels in US companies. This generated an interest among scholars in studying the relationship between educational background and innovation. Scherer and Huh analysed data over a period of 17 years on R&D expenditures and looked for a relationship between the educational background of CEOs for 221 research-intensive U.S. corporations and R&D expenditures (Scherer and Huh, 1992). They found that, when controlled for profitability and the industrial fields in which the firms operate, a science or engineering degree was linked to more intensive R&D expenditure. Barker and Mueller (Barker and Mueller, 2002) took this research further and investigated the effect of CEO characteristics on firm R&D spending. They collected data from the business reports of 172 firms and found a significant effect of CEO's education on R&D spending in the firm, even when they controlled for corporate strategy, ownership structure and other firm attributes. For example, they observed that

once a CEO has a university degree, the education received above this level did not play a role in R&D spending. The presence of a science degrees has an important influence on R&D spending in the firm. Having a CEO with a business degree as a formal education did not influence R&D expenditure, whilst CEOs with a legal degree impacted R&D expenditure negatively. Lynskey (Lynskey, 2004) approached the role of the CEO in high-technology start-up firms by looking into the effect of the level of CEO education on the number of patents issued and new products developed. It was observed that managerial characteristics did not influence the number of products, but CEOs who held a post-graduate university degree and who were members of networks with other researchers, led companies owning a higher number of patents, but not necessarily a higher number of new products. Using a World Bank survey of 1,088 private manufacturing firms covering the period 2000 to 2002, Lin et al. (2002) observed that the level of CEO education and professional background were positively linked to a firm's innovation effort. Firms headed by a CEO with a university education combined with a professional background tended to invest more in R&D projects and manage firms with higher R&D intensity. Kitchell (Kitchell, 1997) found that CEOs trained in engineering had a significant positive effect on technology adoption.

Datta and Guthrie (Datta and Guthrie, 1994b) showed that R&D-intensive firms were more likely to hire CEOs with technical backgrounds whilst the level of education of the CEO was positively associated with higher R&D intensity, corroborating other results in companies but contradicting results obtained in public organizations by Damanpour and Schneider (Damanpour and Schneider, 2006). Other data by Young et al. (Young et al., 2001) showed that better-educated managers are more skilled in identifying innovations from the stream of ideas to which managers are exposed. In summary, several studies support the idea that CEOs' education and science and engineering degrees positively impact innovation. Tyler and Steensma (Tyler and Steensma, 1998) found that technical education and perceived technological emphasis by the firm, risk orientation and previous success with collaborative activities moderated an executive's weighing of alliances. Top executives with a technical education focused more on an item of information that represented an opportunity for the firm than did executives without a technical education. Technically trained executives did not focus less on information related to threats than executives with non-technical education. These findings suggest that undergraduate technical education has a greater impact than technical work experience on the extent to which executives focus on the technological opportunities associated with technological alliances.

CEO age and tenure

The nature of R&D innovation is such that it is subject to a high degree of freedom – the freedom to take a selected scientific approach to an issue at hand, to hold different views on how problems may be solved and to choose different directions in developing products. This means that CEOs who run companies where decisions are made on the basis of scientific data should be sufficiently open to risk-taking and adopt an attitude conducive to open-mindedness and a free exchange of ideas (Hambrick et al., 1992). According to Hambrick (Hambrick, 1987), it is expected that in high-discretion situations,

chief executives tend to be relatively young. The question whether the age of CEOs impacts upon the innovational output (or culture) of a firm is a long-standing one and it is argued that younger CEOs have greater open-mindedness, exchange ideas more freely and are more willing to take risky approaches to firm growth. As stated earlier, Damanpour and Schneider's data do not support these claims but this inconsistency may be due to the fact that their study was conducted in not-for profit organizations. The results presented by Young et al. (Young et al., 2001) are consistent with earlier research showing that younger and better-educated top managers are more inclined to adopt innovations. Younger managers may have less of an emotional commitment to a particular way of managing and thus are more receptive to new ideas. R&D spending, for example, is higher when CEOs are younger and have career experience in output functions such as sales/marketing and R&D/engineering (Barker and Mueller, 2002). Kitchell found that the effect of the CEO's age is negative-curvilinear, meaning that the older the CEO is, the less inclined he/she is to engage in high-risk innovation ventures.

Other studies found the effect of CEO tenure on innovation to be positive and highly significant (Miller, 1991). This finding supports Hayes and Abernathy's view (Hayes and Abernathy, 1980) that constant job change among corporate CEOs may reward the individuals involved, but the resulting short-term focus, inadequate information processing and lack of commitment might seriously detract from technology advancement for the corporation. CEOs spend less on R&D during their final years in office (Dechow and Sloan, 1991) although other data show that when CEOs stay with the firm longer, the investment in R&D increases, possibly because the CEO has collected experience and can shape the R&D to fit his/her own vision (Barker and Mueller, 2002). In other words, CEOs spend R&D dollars for R&D in a specific field of science and engineering only if he/she feels comfortable with the nature of the scientific or technological aspects of the market. Young et al. (Young et al., 2001) did not observe a significant effect of tenure, which confirm the inconclusiveness of the empirical research addressing this demographic variable.

CEO experience

As part of the factors that contribute to CEO strategy formulation, previous work experience may be a determining factor. On the basis of a data set of 101 small manufacturing firms, research supports the hypothesis that the positive effect of prior experience of a CEO on firm performance increases when the firm emphasizes innovation differentiation (Beal and Yasai-Ardekani, 2000). R&D spending is higher when CEOs have career experience in output functions such as sales/marketing and R&D/engineering (Barker and Mueller, 2002). In pharmaceutical biotech companies the effect of a CEO's experience in managing commercial R&D facilities positively impacts the R&D capabilities of the firm (Deeds et al., 2000). When CEOs have manufacturing experience, they engage more in innovative manufacturing facilities and technology policies. The background of the CEO is translated into strong technology-driven manufacturing plants and in a hiring policy to attract technical talent (Ettlie, 1990). In line with these observations, it was shown that top executives' experiences and perceptions influence their attitudes toward technological alliance formation. For example, Tyler and Steensma showed that executive experiences and perceptions

influence their assessments of potential technological alliances (Tyler and Steensma, 1998). Hambrick, Black and Fredrickson (Hambrick et al., 1992) observed that companies with intensive R&D tend to have CEOs with technical (e.g. R&D) experience. Datta and Guthrie examined this relationship at the time of succession between CEOs and found that R&D-intensive firms select CEOs with technical (R&D, engineering or manufacturing) experience (Datta et al., 2002). The replacement of top executives is an important step in triggering innovation in such a situation (Nutt and Backoff, 1997; Chaganti et al., 2001). In more innovative companies, the CEO's background was in either sales and/or management accounting, whilst the CEO in less innovative companies had an engineering background (Laforet and Tann, 2006). CEOs trained in engineering had a significant effect on technology adoption (Kitchell, 1997) which is consistent with the view of Lefebvre and Lefebvre (1992) that CEOs' functional experience is important and with Ettlie's observations that CEOs with an engineering background implement an aggressive technology adoption policy (Ettlie, 1990). CEOs with international work experience have a positive, highly significant and curvilinear effect on corporate innovativeness: it allows managers to be exposed to different approaches in management, products and innovation. Increased and continual international exposure, however, prevents CEOs from 'settling' and focusing on specific innovation tasks, which may explain the curvilinear relationship (Ettlie, 1990) Daellenbach et al. observed a relationship between the technical orientation of the top management team and CEO, on the one hand and above-average R&D intensity, on the other hand (Daellenbach et al., 1999).

Summary of the granular research data using the upper echelon perspective
The following conclusions can be drawn:

i. CEO demographics are much less important than CEO attitude and personality in driving innovation and they are a poor predictor of innovation. CEO attitude towards innovation and the appropriate organizational environment are more important drivers of innovation. New product introduction is driven by CEO personality to a greater extent than by organizational and environmental characteristics.
ii. Although at first sight, CEO demographics do not predict discontinuous innovation, the latter decreases with the age of the firm but more rapidly with older CEOs; decreases with the size of the firm but more rapidly with long-tenured CEOs; it increases with the number of intra-firm linkages but more rapidly with younger CEOs, all of which shows that CEO demographics may play a role but that this role is context-driven.
iii. Increasing CEO tenure increases a firm's inventiveness during a first phase but inventiveness starts to decrease with prolonged CEO tenure. In very dynamic environments, the longer the CEO tenure, the more dramatic the decline of a firm's inventiveness, whilst in low-dynamic environments, the increase in CEO tenure increases a firm's inventiveness, which, however, levels off with long CEO tenure.

iv. Better educated managers are more skilled in identifying innovations from the stream of ideas to which managers are exposed. CEOs' education and in particular science and engineering degrees impact positively on innovation.
v. Younger (and better educated) top managers are more inclined to engage in change initiatives and adopt innovations. R&D spending is higher when CEOs are younger and have substantial firm stock and career experience in output functions such as sales/marketing and R&D/engineering.
vi. The effect of CEO age is negative-curvilinear and significant, in that the older the CEO, the less inclined he/she is to engage in high-risk innovation ventures.
vii. CEOs spend less on R&D during their final years in office. When CEOs stay with a firm longer, the investment in R&D increases. However, a significant effect for tenure was not found further, which adds to the conflicting empirical research addressing this demographic variable.
viii. CEO tenure indirectly influences performance through its direct influences on TMT risk-taking propensity and a firm's pursuit of entrepreneurial initiatives.

CEO education and experience

The following conclusions can be drawn:

i. When controlled for profitability and the industrial areas in which the firms operate, a science or engineering degree is linked to more intensive R&D expenditure.
ii. A CEO with a business degree does not influence R&D expenditure, whilst a CEO with a legal degree influences R&D expenditure negatively.
iii. Managerial characteristics do not influence the number of products developed, but CEOs who hold post graduate university degrees and who are members of networks of other researchers lead companies owning a higher number of patents, but not necessarily a higher number of new products.
iv. Firms headed by a CEO with a university education combined with a professional background tend to invest more in R&D projects and manage firms with higher R&D intensity than firms led by CEOs who were once a government official. A background in engineering has a significant effect on the extent to which a CEO adopts a new technology.
v. R&D-intensive firms are more likely to hire a CEO with a technical background, whereas the level of education of the CEO is positively associated with R&D intensity.
vi. R&D spending is higher when CEOs have career experience in output functions such as sales/marketing and R&D/engineering. In pharmaceutical biotech companies the effect of a CEO's experience in managing commercial R&D facilities has a clear and positive impact on the R&D capabilities of the firm. When CEOs have manufacturing experience, they are more willing to engage in substantial innovative improvements into manufacturing facilities and to adopt a significantly more aggressive manufacturing technology policy of implementing strategies.
vii. Companies with intensive R&D tend to have CEOs with technical (e.g., R&D) functional experience. R&D-intensive firms select CEOs with technical (R&D,

engineering or manufacturing) experience. In more innovative companies, the CEOs tend to have a background in either sales or management accounting or both, whilst in less innovative companies the CEO tends to have engineering background.

viii. CEOs with international work experience have a positive, highly significant and curvilinear effect on corporate innovativeness

ix. There is a relationship between technically orientated TMT and CEOs with an above-average R&D intensity. CEO flexibility is associated with risk-embracing decision-making.

x. CEOs who exploit differences in background and perspectives within their TMT, are able to channel these differences into creative discussion and debate regarding the assessment opportunities for their organization.

CEO Leadership

The following conclusions can be drawn:

i. There is a positive relationship between the transformational leadership style of the CEO and the innovation within the organization, whilst environment (uncertainty and competition) and firm-level characteristics (innovational climate, formalization, centralization and empowerment) have moderating effects on the aforementioned relationship.

ii. CEO transformational leadership is positively associated with, and accounts for, additional variance in risk propensity, which in turn is related to corporate entrepreneurship.

CEO attention, involvement, innovativeness and perception

The following conclusions can be drawn:

i. The impact of a CEO is a function of his/her attentional focus: product launch is accelerated when attention is directed to a new emerging technology and delayed when attention is directed to the existing technology. When a CEO focuses his/her attention on an emerging technology, the CEO's impact is also dependent on the level of organizational orientation a firm has toward the affected industry. The accelerative impact of a CEO's attention to a new opportunity matters more when firms have greater capabilities with reference to this technology.

ii. CEOs with an internal locus of control tend to pursue more product innovation, tend to be more future-oriented, and tend to tailor their approaches to the circumstances facing their firms than CEOs who have an external locus of control.

iii. The performance of an NPD-strategy and of the elements that constitute this strategy (such as customisation, new product introduction, design innovation, product development cycle time, product technological innovation, product improvement, and original product development) is linked to the importance that the CEO attaches to that activity.

iv. In the more innovative companies, the CEO is much more involved in developing new products and ways of working than in the less innovative companies.

v. Lack of top management commitment seems to necessitate effective cross-functional communication flows if new product development is to proceed properly.
vi. A CEO's flexibility and perseverance play a substantial role in driving innovation. Data suggest that a CEO's flexibility predict innovation adoption.
vii. CEO innovativeness is a significant factor in the adoption of technological innovations such as the use of external e-mail in SMEs.
viii. Small businesses with CEOs who are more knowledgeable about IT are more likely to adopt IT.
ix. CEO perception – and not factual environmental data– seems to be potential driver in the development of a technology policy and innovation realization.
x. If a CEO perceives the environment as dynamic, the positive effect of a technology policy on realized innovation efforts (i.e. R&D investments, internal innovations such as adoption of IT or improved manufacturing technologies and searches for and evaluations of external technology) will increase. If, however, the CEO perceives his/her environment as hostile, the realized innovation efforts with reference to R&D and internal innovation will be dampened.
xi. Executives who perceive their firms as emphasizing technology and who have scored successes with previous technological alliances, attach more importance to opportunity-based information and less importance to threat-based information than executives who perceive their firms as placing less emphasis on technology and having had been less successful with previous technological alliances.

TMT and board relationship

The following conclusions can be drawn:

i. Board involvement in decisions made by the CEO results in an inverted U-shaped relationship to NPI performance; board involvement is linked to a poorer performance of new product introduction in conditions of greater market instability; social ties between board and CEOs have an inverted U-shaped relationship with NPI performance.
ii. CEOs draw on the functional differences between management team members to enhance the opportunity-assessment process and tap into the diversity of perspectives present within their TMTs in order to foster openness and creative exploration.

The tables below present an overview of the literature data of the impact of CEO characteristics on innovation and an overview of the data obtained by Damanpour and Schneider (2006) and Papadakis and Bourantas (1998)

Effect of CEO personality, demographics and experience on innovation parameters									
Variable	**Context**	**CI**	**$**	**P**	**NP**	**DI**	**IA**	**TA**	
CEO personality									
Flexibility	MMWF								Kitchell
Flexibility	SF	ni							Miller & Toulouse
Perseverance	MMWF								Kitchell
Risk taking	MMWF					ni			Kitchell
Attitude towards risk	SMF								Lefebvre & Lefebvre

Proactive attitude	SMF								Lefebvre & Lefebvre
Need for achievement	SF	ni							Miller & Toulouse
Internal locus of control	SF								Miller & Toulouse
Internal locus of control	SMF								Lefebvre & Lefebvre
External search for information	SMF								Lefebvre & Lefebvre
Internal search for information	SMF								Lefebvre & Lefebvre
Futurity	SMF								Lefebvre & Lefebvre
Analytical ability	SMF								Lefebvre & Lefebvre
Strategic awareness	SMF								Lefebvre & Lefebvre
CEO demographics									
Tenure									
Higher tenure	RDF								Barker & Mueller
Higher tenure	CMF		m						Lin et al.
Higher tenure	PH						ni		Young et al.
Tenure	SMF	ni							Lefebvre & Lefebvre
Years in the sector	SMF	ni							Lefebvre & Lefebvre
Tenure	BIO	IU							Wu et al.
Age									
Young age	RDF			ni	ni				Barker & Mueller
Young age	MMWF					C			Kitchell
Young age	PH								Young et al.
Young age	CEOs								Tyler & Steensma
Experience									
Finance /accounting experience	RDF		ni						Barker & Mueller
Finance /accounting experience	SMF								Lefebvre & Lefebvre
Legal career experience	RDF								Barker & Mueller
Productions/operations experience	RDF								Barker & Mueller
Engineering/production experience	SMF								Lefebvre & Lefebvre
HR experience	SMF								Lefebvre & Lefebvre
Manufacturing experience	SMF								Ettlie
Technical background	CSF								Datta & Guthrie
Technical background	CEOs								Tyler & Steensma
Administration experience	RDF		ni						Barker & Mueller
Marketing experience	RDF								Barker & Mueller
Marketing experience	SMF	ni							Lefebvre & Lefebvre
Engineering/R&D experience	RDF								Barker & Mueller
R&D experience	JSU			ni	ni				Lysnkey
Education									
Number of business degrees	RDF		ni						Barker & Mueller
Legal degree(s)	RDF								Barker & Mueller
Nr of science-engineering degrees	RDF								Barker & Mueller
University degree	JSU				ni				Lysnkey
Graduate degree	PH								Young et al.
Research network	JSU				ni				Lysnkey
Experience as CEO	JSU			ni	ni				Lysnkey
Education level	RDF		ni						Barker & Mueller
Education level	CSF								Datta & Guthrie
Education level	SMF								Lefebvre & Lefebvre
Experience as R&D manager	BIO								Deeds et al.
Education as an engineer	MMWF								Kitchell
CEO college education	CMF								Lin et al.
CEO professional experience	CMF								Lin et al.
CEO political connection	CMF								Lin et al.
Other									
Higher value of stock holdings	RDF								Barker & Mueller
CEO founder	JSU			ni	ni				Lysnkey
CEO close to retirement	LC								Dechow & Sloan
Immigrant status	MMWF								Kitchell
International work experience	MMWF								Kitchell

	Increased innovation		Decreased innovation		No impact				

Legend: CI: corporate innovativeness; $: R&D spending; P: number of new patents; NP: number of new products; ni: no impact; m: marginal; DI: discontinuous innovation: C: relationship is curvilinear; IA: innovation adoption; CI: corporate innovation level; IU: inverted U relationship; TA: positive evaluation of technological alliances; SMF: small manufacturing firms; PH: public hospitals; CEOs: sample of CEOs graduated from a US university; BIO: publicly traded US biotech companies; LC: large firms (in

case of Dechow: 405 firms in 14 SIC industry classifications); SF: small firms; MMWF: machinery and metal working firms; CMF: Chinese manufacturing firms; RDF: R&D firms; JSU: Japanese start-up; CSF: CEO succession firms

Summary Damanpour and Schneider (2006) and Papadakis and Bourantas (1998)	**Innovation parameters**								
Variable	**IN**	**AD**	**IM**	**NPI**	**SPI**	**IPI**	**IPP**	**DI**	**ATC**
Environmental factors									
Urbanisation				-	-	-	-	-	-
Community wealth				-	-	-	-	-	-
Population growth				-	-	-	-	-	-
Unemployment rate	-	-	-	-	-	-	-	-	-
Environmental dynamisms	-	-	-						-
Organizational characteristics									
Structural organicity	-	-	-					-	-
Complexity of the organization				-	-	-	-	-	-
Firm size				-	-	-	-		-
Economic health	-			-	-	-	-	-	-
Unions present in firms				-	-	-	-	-	-
External communication				-	-	-	-	-	-
Rational analytical decision-making	-	-	-					-	-
Use of consultants	-	-	-					-	-
Firm age	-	-	-	-	-	-	-		-
Improvisation culture	-	-	-	-	-	-	-		-
Experimentation culture	-	-	-	-	-	-	-		-
Transitioning	-	-	-	-	-	-	-		-
Firm orientation to existing technology	-	-	-	-	-	-	-	-	
CEO personality									
Need for achievement	-	-	-					-	-
Goal of reputation	-	-	-					-	-
Goal of power	-	-	-					-	-
Locus of control	-	-	-					-	-
Attitude to risk	-	-	-					-	-
Favouring competition				-	-	-	-	-	-
Entrepreneurial attitude				-	-	-	-	-	-
Attention	-	-	-	-	-	-	-	-	FO
CEO demographics									
Tenure	-	-	-					F/ D	-
Formal education	-	-	-					-	-
Age				-	-	-	-	F	-
Gender				-	-	-	-	-	-
Education				-	-	-	-	-	-
Tenure in position				-	-	-	-	-	
Tenure in management				-	-	-	-	-	
		Stat. significant				Stat. Insignificant			

Legend: IN: innovation initiation; AD: innovation adoption decision; IM: innovation implementation; NPI: new product innovation: SPI: significant product introduction; IPI: incremental product innovation; IPP: innovation of the production process; DI: discontinuous innovation: ATC: adaptation to technical change; F: CEO demographics age and tenure play a role when firm size, age and intra-linkages are taken into account; FO: impact of CEO on technical reorientation depends on firm orientation towards existing technology; -: not measured; D: environmental dynamisms moderates the effect of tenure

Appendix C. Alternative theories for the study of the CEO

The role of the CEO in innovation was approached in the literature through the lenses of upper-echelons and transformational theory and by exploring the role behaviors that were topic of previous research. However, whether these approaches provide the most appropriate background for understanding the role of the CEO in innovation is a valid question. At the start of the literature review it was realised that a systematic review based on specifically selected search terms would miss a key area of the leadership literature that addresses leadership theories and concepts that may be of value in elucidating the role of the CEO in innovation, but were not yet explored. The objective of this section is not to attempt to offer a comprehensive overview and analysis of untested theories and models, but instead to explore alternatives in the research into the role of the CEO in innovation, without trying to achieve completeness either through scope or depth. Two sources were used: 'Leadership' by Northouse (Northouse, 2010) and a recent review paper by Avolio (Avolio et al., 2009). The table below presents an overview of the leadership theories presented in these works, a reference in the review article to "innovation", the number of hits retrieved from a database search (ABI/Inform) in which the theory was referred to (in the title) and the citation/abstract in the paper. The table shows that various leadership theories are not or very rarely used in the context of innovation.

Authentic leadership. The concept of authentic leadership is still in its initial stages of development and is emerging in the social sciences (Northouse, 2010). It holds promise for explaining the underlying processes by which authentic leaders and followers influence work outcomes and organizational performance. Authentic leadership has four components: self-awareness, internalised moral perspective, balanced processing and transparency. The development of this kind of leadership is a complex process whereby leaders are perceived by followers as trustworthy and believable. It is thought to be a lifelong process that is influenced by critical life events and tries to determine what is truly good for the leader, the followers and the organization. Whether this theory has the potential to yield insight in an innovative context is doubtful as its tenets do not contain specific factors and determinants that might prove useful for an organization's quest to become more innovative.

New-genre leadership is a leadership perspective that contains the transformational leadership behavior that is quite well studied in the context of innovation at the team level. However, it is used sparingly at the level of the CEO and top management. Further studies are definitely required to explore the effect of transformational leadership and the diffusion of this leadership style throughout the organization (Avolio et al., 2009)

Complexity leadership. In traditional leadership theory, the units of analyses are the leader, the leader and the follower and the leader and the group. The fundamental unit of analysis in complexity leadership is the 'Complex Adaptive System' or 'CAS' (Avolio et

al., 2009). In complexity leadership, three leadership roles are identified: adaptive (engaging others in brainstorming to overcome challenges), administrative (formal planning) and enabling (minimising bureaucratic constraints). This form of leadership is studied by means of micro-observations (i.e. daily interactions through real-time observation), meso interactions (the use of social network analysis in which one examines a group of agents and how they are linked over time) and macro interactions (whereby historical analysis of longer lasting events is conducted). This theory may offer interesting perspectives for understanding the role of the CEO in the context of R&D as it may elucidate the relationship between the CEO and the R&D function through an analysis of events that occur on a day-to-day basis or over longer time periods with the aim of determining how both actors interact.

Shared, collective or distributed leadership is an emergent state whereby leadership is developed over time by teams and team members. Avolio studied shared leadership by rating the teams instead of the team leaders (Avolio and Bass, 1995). The value of using shared leadership in an attempt to study the role and impact of a CEO in innovation is rather limited because the unit of analysis from which the theory proceeds is a team or a group of individuals.

Followership and leadership: the follower-and-leader concept proposes a social constructionist theory to describe the relationship between leadership and followership (Avolio et al., 2009). This theory may offer interesting perspectives on the role of the CEO in innovation as it may show how leaders (CEOs) are perceived by their followers (innovators, R&D function) as regards their effectiveness in leading innovation and how this perception translates into innovational output or performance.

Servant leadership. This leadership theory refers to the leader's values, namely integrity, empathy, competence and agreeableness and their effect on the followers' attitude, satisfaction, concern for the safety of others, commitment etc. This theory has nothing to recommend in terms of its suitability of researching innovation and the role of the CEO.

Spirituality and leadership. Spiritual leadership is defined as leadership that is comprised of the values, attitudes and behaviors that are necessary to intrinsically motivate one's self and others so that they have a sense of spiritual survival thanks through calling and membership (Avolio et al., 2009).

Discretionary leadership. According to Kakabadse and Kakabadse (1999), the under-lying assumption of discretionary leadership is that irrespective of the nature and qualities of every human being, leaders are only leaders when filling a leadership role. A discretionary role is one whose major elements are determined by the role of the occupant, i.e. in this case, by the leader, whilst the role of the middle-manager is prescribed by structured tasks. The operational latitude that a CEO has depends on the environmental conditions and organizational characteristics. In highly turbulent environmental conditions, his/her discretionary power is more limited than it is with environmental conditions of relative calmness. This means that the impact of the CEO

on innovation is not driven only by the leadership behavior or by the mere fact of his/her top position but also by his/her discretionary freedom.

Close and distant leadership. In addition to the theoretical perspectives offered above, the literature also presents alternative views that may be useful as testing ground for the study of the role of the CEO in innovation. Waldman and Yammarino present a theoretical model of CEO charismatic leadership in organizations and show how this leadership behavior can impact organizational performance (Waldman and Yammarino, 1999). The authors base their model on the 'mixed-effect' model of Klein (1994) whereby CEO leadership behavior affects individual employee effort, but also group performance or organizational performance. In their description of the model for studying the role of charismatic leadership, the authors propose the concept of "close and distant" leadership as a means of understanding the dynamics of CEO leadership. Waldman and Yammarino state that future research involving top leaders should be geared towards the collection of leadership data from both close and distant followers. In addition, the authors argue that leadership can either cascade from higher to lower echelons or – alternatively – can bypass directly to lower echelons (Yammarino et al., 1998).

Role based leadership is leadership whereby leadership roles are sorted into four distinct types: legitimate (the leader is publicly appointed to lead the team), social (defined as the role played by the individual who undertakes to build a network of relationships with other team members), tasks (leaders who play a role by allocating responsibility for delivering a specific task) and macro (the role played by the individual – a senior manager –who leads on the basis of a "macro" view of the organization (Sheard and Kakabadse, 2007). Sheard and Kakabadse developed the role-based leadership model maintaining that by 'recognising the roles of others and by becoming aware of the range of roles that are available to the self, executives learn to modify their behavior to take account of the situation'. CEOs may then learn to modify their behaviors to take into account the peculiarities of the R&D context. These concepts may offer valuable perspectives for the study of the role of the CEO in an innovational context as it permits the study of that role by analysing it in a structured way and by moving away from the search for causal demographic or personality factors which has dominated the research into the role of the CEO in innovation during the previous decades. In other words, studying the actual role of CEOs is an interesting alternative to the upper-echelon and transformational frameworks.

Although leadership and the influence tactics that leaders use affect a follower's willingness to engage in creative ventures (Mumford et al., 2002), research into leader influence on creativity and innovation has been scarce (Mumford et al., 2002; Cummings and Oldham, 1997; Tierney et al., 1999). Most studies in strategic leadership that looked at this subject (Jung et al., 2008; Elenkov et al., 2005) have used traditional conceptualizations of transactional and transformational leadership (Bass, 1985) to capture CEO leadership characteristics. Although these conceptualizations can be used to investigate the relationship between CEOs and followers, strategic leadership in the context of high-technology firms, and firms with extensive R&D capabilities, requires

constructs that bear on the effectiveness of a CEO in fostering not only invention and innovation but also commercialisation of the inventions and developed products. There is a need to refine the constructs that measure creative leadership not only to reflect the CEO's ability to commercialize existing knowledge and derive profit from it, but also to create knowledge (Makri and Scandura, 2010). In other words, constructs - or a set of constructs - are needed that allow a more encompassing view of the role of the CEO then leadership style alone. As discussed above, Elenkov et al. observed that strategic leadership behaviors increase the executive's influence on innovation, whilst Jung et al. (2008) found transformational leadership to be valuable in fostering innovation in firms. According to Makri and Scandura, the multifactor leadership questionnaire used in studies using the transformational leadership perspective, does not fully capture the unique challenges of the CEO of a high-technology firm in that it reflects only relationships between leaders and members. According to these authors, the role of the CEO in a high-technology firm is more related to the creation of a culture that supports innovation than to direct interactions with employees. Therefore, Makri and Scandrura introduced two new leadership concepts, which were termed creative and operational to describe the role of a high-technology CEO. Introducing two dimensions of strategic leadership was meant to suggest that an effective leader is one who is able to simultaneously invent, develop, and commercialize:

i. The operational component of the CEO's strategic leadership concept addresses the ability of a CEO to 'to sense new market needs, develop new concepts for products and services, and increase the knowledge diversity in the firm by diversifying into new products/markets via mergers, alliances or acquisitions' (Kuhn, 1970). A successful operational leader identifies important but not yet clearly recognizable and future opportunities, acts as a 'knowledge scout' whilst playing a role as 'boundary spanner' of the firm. The role of a CEO in innovation also depends upon the ability of the CEO to drive the inventions through the development pipeline, to allow these to be introduced into a manufacturing environment and to market and sell them. Therefore the operational leadership component of strategic leadership in an innovative setting takes into account resources needed and communications necessary to guide the new product through the pipeline and onto the market. Makri and Scandura state:

> '*A CEO who exhibits characteristics of operational leadership would have an external focus when it comes to innovation and would be skilled at communicating with the external environment and broadening the firm's knowledge-creation opportunities by external knowledge acquisition*'

Leadership theory:	Definition (as presented in the literature)	Reference to "innovation" in source review article	Use of theory in innovational setting – No of hits in *title*- in scholarly journals (ABI/Inform)	Use of theory in innovational context – No of hits in *citation & abstracts* - in scholarly journals (ABI/Inform)
Authentic Leadership	A pattern of transparent and ethical leader behaviors that encourages openness in sharing information needed to make decisions and in which followers' inputs are accepted	no	0	**6**
New genre leadership	Leadership emphasizing charismatic leader behavior, visionary, inspiring, ideological and moral values, as well as transformational leadership such as individualized attention, and intellectual stimulation	no	See Chapter 2	See Chapter 2
Complexity leadership	The fundamental unit of analysis in complexity leadership is referred to as a complex adaptive system, or CAS, composed of interdependent agents that can operate simultaneously on the basis of certain rules and localized knowledge that governs the CAS, whilst also being able to adapt and emerge on the basis of feedback from the system	no	**2**	**85**
Shared leadership	A dynamic, interactive influence process among individuals in groups which the objective is to lead one another to the achievement of group or organizational goals or both. This influence process often involves peer, or lateral, influence and at other times involves upward or downward hierarchical influence	no	0	**85**
Collective leadership		no	0	**42**
Distributed leadership		no	0	**22**
Leader Member Exchange	The central principle in LMX theory is that leaders develop different exchange relationships with their followers, whereby the quality of the relationship alters the impact on important leader and member outcomes. Thus, leadership occurs when leaders and followers are able to develop effective relationships that result in mutual and incremental influence	no	See Chapter 2	See Chapter 2
Follower and leadership	A social constructionist theory to describe the relationship between leadership and followership. It is argued that leadership is significantly affected by the way followers construct their understanding of the leader in terms of their interpretation of his/her personality, behaviors, and effectiveness	no	**5**	**81**
Leadership substitutes	The substitutes-for-leadership theory focuses on situational factors that enhance, neutralize, and/or totally substitute for leadership. For example, a group of people engaged in electronic brainstorming using technology, such as a group decision support system, may operate as though there was a participative leader who was leading the group, but in fact, leadership comes from the operating rules for using the system in order to become engaged.	no	0	**9**
Servant leadership	Ten characteristics representing a servant leader: (*a*) listening, (*b*) empathy, (*c*) healing, (*d*) awareness, (*e*) persuasion, (*f*) conceptualization, (*g*) foresight, (*h*) stewardship, (*i*) commitment, and (*j*) community building	no	0	**7**
Spirituality leadership	The research on workplace spirituality also now includes a focus on spiritual leadership—defined as "comprising the values, attitudes, and behaviors that are necessary to intrinsically motivate one's self and others so that they have a sense of spiritual survival through calling and membership"	no	0	**6**

Cross cultural leadership	The examination of leadership in multicultural contexts	no	0	**26**
Discretio-nary leadership	Leaders are only leaders when filling a leadership role and managerial work is categorized as prescribed, namely structured, leaving the individual little room to exercise judgment, and discretionary, whereby considerable judgment is necessary in order for the individual to function effectively in the role.	no	0	**1**
Role based leadership Theory	Leadership roles are categorized along four distinct types: legitimate, social , tasks and macro.	no	0	0

ii. The second component of CEO strategic leadership in an innovative setting is creative leadership. Creative leaders are more apt to develop human and social capital and also to create an environment that fosters innovation (Mumford et al., 2002). Creative leaders are capable of stimulating creative subordinates intellectually, and offer support for and trust in potentially high-risk projects. By doing so, they allow individual initiatives and possibly integrate activities from different fields of expertise in the firm (Mumford et al., 2002). This allows the development of a culture of innovation which has been shown to be an important driver of innovative activities (Scott and Bruce, 1994; Jung et al., 2008; Bain et al., 2001; Jung et al., 2003). 'High-technology firms benefit from CEOs who are capable of fostering innovation by catalyzing and exploiting the talents of the firm's technical professionals. These (successful) CEOs are very collaborative, open-minded and energetic. Even though these seem like universally ideal qualities for a CEO, they appear to be particularly important in the high-technology firm which has to deal with rapid and discontinuous change, with value creation being dependent on a staff of high-grade technical professionals' (Hambrick et al., 1992).

Makri and Scandura's view of a CEO who is successful in innovation is linked to two aspects of new product innovation: exploration and exploitation. The challenge in innovation in high tech companies resides in the ability to shift from knowledge creation and exploration to knowledge application and exploitation. Makri and Scandura suggest that for high-technology firms, effective leadership calls for a CEO who is adept at fostering invention internally by catalysing and supporting the talents of the firm's technical professionals and encouraging both science-based and technology-based initiatives. Effective leadership calls for a CEO who can also simultaneously create opportunities for new knowledge creation and existing knowledge application by identifying and exploiting opportunities in the external environment. This highlights two important skill sets that a CEO should possess: that of a creative leader, who is people-centred and focuses on internal knowledge development and exploration and that of an operational leader, who is constantly on the lookout for new opportunities that can be exploited.

Conclusion

When the role of the CEO in innovation was studied, research was conducted in an attempt to identify CEO-factors that that might impact innovation, such as the CEO's educational background. However, trying to understand the role of the CEO through this approach reduces the role of the CEO to a search for causal factors and it does not elucidate the roles that CEOs play in R&D and how these can be understood. The review of the literature did not identify a research paper that presents research conducted in an attempt to understand the actual role of the CEO. However, the literature identified a number of role descriptions If the objective is to understand the roles that CEOs play in innovation we need to switch our approach away from the search for predictive factors. The literature has learned that:

- role behaviors of CEOs such as his/her attitude towards innovation, attention to the future, commitment to projects, involvement in innovation and even innovativeness may offer an interesting avenue to understand the role of the CEO
- a number of theoretical frameworks call for a role based research perspective such as the role based theory of leadership developed by Sheard and Kakabadse (2006) and the exploitation/exploration roles proposed by Makri and Scandura, posited to be necessary for high tech CEOs

Appendix D. Literature study of behavioral role concepts of CEOs in innovation

The following is a comprehensive overview of the behavioral role concepts of attitude, attention, commitment, involvement and innovativeness as studied in the literature on the role of the CEO in innovation.

Attitude towards innovation. Perhaps the most influential people, affecting innovation and change in organizations are top executives (Damanpour and Schneider, 2006). Studies of organizational innovation have shown 'that senior executives influence the adoption of innovation by creating a favorable climate toward innovation' (Damanpour, 1991;Dewar and Dutton; 1986; Hage and Dewar, 1973). Therefore top manager's attitude toward change influence organizational climate conducive to innovation' (Ekvall, 1996; Hoffman and Hegarty, 1993; West and Anderson, 1996, cited by Damanpour and Schneider, 2006). Hage and Dewar observed that leader factors were more important in predicting innovative output than organizational factors (Hage and Dewar, 1973, cited by Damanpour and Schneider, 2006). According to Ekvall and Arvonen (1991) and Yukl (1999), cited by Damanpour and Schneider (2006):

> 'In addition to task-oriented and employee-oriented behaviors, studies of leadership behavior have found a third dimension, often referred to as change-oriented behavior. This leadership dimension entails an executive who takes long-term perspectives, describes appealing visions, encourages and accepts new ideas and forges agreements and approvals with people inside and outside of the organization to initiate and implement change'

This third dimension is referred to as the 'attitude towards innovation'. A positive attitude towards innovation facilitates the adoption of innovation by creating a favorable climate for innovation (Damanpour, 1991; Dewar and Dutton, 1986; Hage and Dewar, 1973). Organizations led by managers with unfavorable attitude towards innovation are most likely not to develop structures and administrative processes required for innovation and do not encourage their members to develop new perceptual frames for innovation (Damanpour and Schneider, 2006). Bang Nam Jeon, in their study of the adoption of e-business in SMEs in Korea, argue that the 'role of CEOs, who are well equipped with knowledge and positive attitudes toward innovation, in adopting and expanding e-business by SMEs cannot be overemphasized' (Bang Nam Jeon et al., 2006). Bang Nam Jeon et al.'s study of the determining factors of e-business adoption defines 'attitude' as a composite factor containing 'CEO innovativeness 1' and 'CEO innovativeness 2' defined respectively as the 'CEO's eagerness to acquire relevant information and skill' and 'the extent to which the CEO feels urgency for a PC training program'. This is in contrast with Damanpour and Schneider (2006) and strategic leadership researchers, who defined 'attitude favoring innovation' as a change oriented behavior that facilitates the adoption of innovation by creating a favorable climate for

innovation. This different interpretation of the concept of 'attitude' illustrates the need for a clear definition.

Attitude towards risk. A 'favorable attitude and willingness to accept occasional failures as a natural component of business positively affects new product performance' (Menon et al., 1997; cited by Sanzo et al., 2012). Transformational leaders, it is argued, are characterized by risk-taking behavior (Conger and Kanungo, 1988) and CEOs who are transformational leaders are hypothesized to create innovational firm output (Jung et al., 2008). Kitchell already suggested that the risk-taking culture of an organization or of an individual is positively associated with innovativeness (Kitchel, 1997). In addition, innovations are characterized by intrinsic risk and uncertainty (Howell and Higgins, 1990). Because innovation is an activity that entails risk, Papadakis and Bourantas looked for a relationship between a CEO's attitude towards risk (risk propensity) and the level of technological innovation in manufacturing enterprises (Papadakis and Bourantas, 1998). The authors did not observe a statistically significant relationship between a CEO's risk attitude and innovation. Kitchell observed that CEOs' flexibility and perseverance are significant factors in driving innovation, corroborating previous studies (Lefebvre and Lefebvre, 1992; Miller and Toulouse, 1986b; Kitchell, 1997; Miller and Toulouse, 1986a). Flexibility was shown to be the best predictor of innovation adoption, which supports Miller and Toulouse's view that flexible CEOs foster a culture that is conducive to innovation adoption (Miller and Toulouse, 1986). The positive effect of perseverance is not surprising as innovation activities demand time and effort if they are to result in profitable outcomes. However, risk-taking does not play a substantial role in driving innovation and, according to Kitchell, this finding 'cannot be explained by the fact that innovative companies are more experienced and knowledgeable adopters of new technology, so that for them, the perceived level of risk is not that high'. If management decisions are based on perceived rather than on actual risks, the innovative CEO may not necessarily be a greater risk taker. On the contrary, innovative CEOs may be 'risk-reducers' as they appreciate their risky ventures better than CEOs who are not engaged in innovative programs and therefore consider themselves as risk-cautious (Lefebvre and Lefebvre, 1992). These observations with respect to risk taking are in line with Dougherty and Heller argument that innovation can be considered an 'illegitimate action' that 'owing to inertial and rigidity forces' either 'violate the existing regime of thinking and acting' or 'fall into a vacuum where no shared understanding exist to make them meaningful' (Dougherty and Heller, 1994). In other words CEOs can be innovative while acting as strong risk reducers. This is in line with Padadakis and Bourantas argument that 'technological innovations should confirm with existing beliefs and practices in order to gain acceptance' and that 'managers should pay particular attention to the manner in which IT proposals are presented to the CEO' and conclude that 'the attitude of the CEO towards the specific innovation is of crucial importance'. One can therefore hypothesize that R&D management, seeking approval from the CEO will need to transform innovational R&D proposals to proposal that not only shows opportunities for the firm but also reduces the risk profile accepted by the CEO and falls within shared understanding.

Attitude towards technological innovation. In a study of small businesses, Thong and Yap observed that CEOs who have a more positive attitude towards adoption of information technology are more likely to adopt information technology (Thong and Yap, 1995) supporting Rogers' model of an individual's innovation-adoption process (Rogers, 2003). According to Rogers, the development of a favorable or unfavorable attitude towards innovation takes place *before* a decision is made to adopt the innovation and depends upon the *perception* of the CEO towards the innovation (Thong and Yap, 1995). The perception of the positive effects of innovation in general or of the positive effects of an innovational technology drives the attitude of the CEO towards the adoption of an innovational culture or an innovational technology. The concept of attitude therefore has two dimensions: either a CEO has a favorable attitude towards innovation as a factor that drives firm growth or he/she has a favorable attitude towards a specific innovational technology that is presented to him/her. In both cases, the CEO's attitude can be conceptualized as a positional stance of the CEO about the need for innovation, the innovational culture that is required for innovation to take place and the uncertainty that is associated with the innovational path and /or technology. As Thong and Yap argue in the context of information technology (IT):

> '(the) formation of a favorable or unfavorable attitude towards an innovation takes place before a decision to adopt is made. In the case of a small business, the chief decision-maker is the CEO. Hence, the CEO's perception of the adoption of IT is of prime importance. As IT is a new innovation to the CEO, he or she has no way of knowing whether it will be superior to existing methods of operations. A degree of uncertainty exists as adoption of IT is risky, and each CEO will perceive the degree of risk or uncertainty associated with IT differently. If the CEO perceives the benefits of IT adoption to outweigh the risks, then the business is more likely to adopt IT'

This is in line with Damanpour and Schneider's argument in that the CEO's discretion to drive innovation (initiation, adoption and implementation) is shaped by his/her attitudes toward innovation in general. This means that the CEO attitude is the starting point from which innovation takes off in the organization. In both Damanpour and Schneider's, Papadakis and Bourantas' and Thong and Yap's research, the concept of attitude is defined as a characteristic of the CEO that identifies him/her as an individual who is inclined to create an innovative culture that allows innovation to take place. A favorable attitude towards innovation or to a technological innovation is based upon the perception of the positive impact of innovation by the CEO who is then inclined or convinced to adopt the technology. In Damanpour and Schneider's study, attitude was defined as a CEO characteristic that challenges the status quo in public organizations by instilling ideas of competitive and entrepreneurial behavior. In Papadakis and Bourantas' study, attitude towards risk was hypothesized to impact on innovation. At first glance, the concept of attitude as used by Damanpour and Schneider and the concept of attitude as used by Papadakis and Bourantas and Thong and Yap differ because the former uses the concept of attitude as a positional stance of the CEO

towards innovation in general while the former use the concept of attitude as a positional stance towards a specific technological innovation. In the case of Damanpour and Schneider, attitude concerns the perception and belief that innovation will drive firm growth while Papadakis and Bourantas and Thong and Yap
refer to attitude as the belief and perception that a specific technology will do the same. In both cases however, the belief in the positive effect of innovation in general or the adoption of an innovational technology is based upon the inherent acceptance of the risk intensity of an innovational undertaking and the culture that will have to drive these undertakings. Attitude in the context of innovation, therefore, is the positional stance of a CEO who agrees that a culture of innovation is required to grow the firm either through the implementation of innovational thinking in the firm and/or through the exploration and use of innovational technologies.

Attitude and perception. CEO perception and not factual environmental data, seem to be potential drivers in the development of a technology policy and innovation realization. Perception seems to be an important parameter driving the decision-making process of a CEO (Lefebvre et al., 1997). If a CEO perceives the environment as dynamic, the positive effect of a technology policy on innovation efforts (i.e. R&D investments, internal innovations such as adoption of IT or improved manufacturing technologies and searches for and evaluations of external technology) will increase. If, however, the CEO perceives his/her environment as hostile, the realized innovation efforts of R&D and of internal innovation will be dampened whereas the external orientation will increase. The practical implications are that misread and/or misinterpreted environments will result in an inadequate technology policy. This in turn will translate into suboptimal allocation of resources, which could be detrimental to the overall performance or survival of a firm. It also means that environmental facts and the interpretations of these facts by the CEOs may influence R&D efforts. According to Lefebvre et al., a CEO's personal view of the world acts as a prism through which data from the environment passes and is differentially weighted to form patterns that make sense to the CEO. Different CEOs interpret the same external environment differently, and these different interpretations lead to the formulation and enactment of distinctive technology policies and to different innovative actions. In another study by Tyler and Steensma (1998), it was found that executives who perceived their firms as emphasizing technology and who had been successful with previous technological alliances, attached more importance to opportunity-based information (i.e. the significance of technology for strategy and the potential for learning) and less importance to threat-based information associated with performance risk (i.e. the potential for decreased development risk, the availability of technological substitutes and the total expected cost of development) than executives who perceived their firms as placing less emphasis on technology and who had been less successful with previous technological alliances. Executives who believed that their firms emphasized technology also focused more on information that could be related to threats associated with relational risk (i.e. the favorability of a potential partner's history of co-operation) than executives who did not have this belief. Likewise, executives who perceived their firms as having been successful with previous technological alliances focused less on information that could be related to threats

associated with relational risk (i.e. the number of potential partners) than executives who did not have this perception. The table below summarizes a number of quotes and statements made by researchers on the concept of attitude and the context in which it is used, but who do not delve deeper in its effect or significance for innovation.

Attitude is defined as 'the state, condition or conjecture of a person, as likely to have a certain result' (Thatcher and McQueen, 1980). The attitude of a CEO in the context of innovation can be defined as follows: A positive attitude in the context of innovation, is the position or stance of a CEO towards the positive effect of innovation on the growth and future of the company and his/her acknowledgment of the conditions that need to be met in order to achieve innovation and which are likely to have a certain result. The attitude of a CEO can be positive (or negative) towards factors that are known to foster innovation such as open communication, exchange of diverse ideas, acceptance of failure, hiring and selection of innovative people (Goffin and Mitchell, 2010). Attitude is a 'positional' conception and starts from the personal point of view an individual CEO has towards innovation. The CEO understands that innovation is necessary for a company to grow and be competitive and understands it is necessary not only in R&D but in all functions of the company. Although attitude is defined as 'the state, condition or conjecture of a person which is *likely* to generate a certain result', it does not on itself *result* in action. In order for an attitude to have effect and result in innovative outcome, attitude will need to be transformed into action. In the case of R&D firms, this action – such as the conduct of R&D - will not materialize unless information is collected in order to take strategic R&D decisions. This information- collecting effort, either from the internal or the external world, is done by drawing attention to pertinent information (Tyler and Steensma, 1998).

CEO attention

In studying of the role of the CEO in innovation, it is important to understand how a CEO's attention to innovation plays a role in new product development processes (NPD), in strategic innovative reorientations or in other innovation-related activities in the firm. Studies have been conducted to gain an understanding of this attentional aspect of the CEO. Attention is defined as 'the noticing, encoding, interpreting and focusing of time and effort by organizational decisions makers' (Ocasio, 1997) or as 'the act of keeping one's mind closely on something or the ability to do this; the mental concentration or mental readiness for such concentration' (Thatcher and McQueen, 1980). Attention to innovation is translated into time and effort that is used by the CEO to focus on innovation. Noticing innovation is the starting point from which other innovation related actions are derived such as commitment to or involvement in innovation. When attention is referred to as defined by Ocasio, attention is the noticing and interpreting of internal or external factors in the environment and the future, as these terms imply time and effort on the part of the CEO. The concept of attention is also linked to perception and sense making of CEOs. According to Tyler and Steensma (1998), in a study exploring the perceptions of top managers on their

Author(s)	Comment	Comment

Datta and Guthrie, 1994	CEOs, are presumed to have a generalist's view (Hambrick and Mason, 1984) are individuals who are usually functionally specialized (Gupta, 1984)and bring to the job knowledge, attitudes and skills which are partly shaped by experience in their primary functional area.	Attitude and functional specialization
Young et al., 2001	Organizational tenure raises conflicting points of view as to its impact on a top manager's attitude toward change and innovation. One point of view is that increasing tenure leads top managers to become stale and resistant to change (Boeker,1997a; Buchholtz and Ribbens, 1994). Top managers with long tenure in their respective organizations are likely to have obligations to existing organizational constituencies that have vested interests in the status quo. The other point of view is that with increasing tenure top managers become betterable to manage the organizational, political, and cultural challenges associated with the adoption of an innovation (Kimberly and Evanisko, 1981;Meyer and Goes, 1988; Arndt and Bigelow, 1995).As a result, managers are more willing to engage in change efforts and to adopt innovations. Although both points of view have theoretical merit, one of the most recent and carefully conducted studies addressing the issue supports the position that with increasing tenure managers become less willing to change (Boeker, 1997a).	Attitude and CEO tenure
Kitchell, 1997	CEOs who have had experience working with foreign nationals in different cultures are also likely to be broader minded and more receptive to new ideas. Hence the general impact of international work experience is hypothesized to be positive. However, Canadian managersare also increasingly reluctant to accept overseas transfers because of the problems of reintegration and benefits of having two incomes in the family. Hence the question of whether the benefits of international work experience are subject to diminishing returns is worth exploring. It is possible that several years of overseas work experience are critical for developing an outward looking and cosmopolitan mind-set. But once these psychological attitudes are funned and an interest in international events developed, additional years of international work experience among CEOs may contribute only marginally to corporate innovativeness.	Attitude and international work experience
Lefebvre et al. (1997)	With respect to technology policy, the prism effect resulting from CEOs' biases cannot be ignored, as technological choices and investments are greatly influenced by managerial attitudes (Ginsberg and Venkatraman 1992) and personal characteristics and personality traits of CEOs(Lefebvre and Lefebvre 1992).	Attitude and perception
Detienne and Koberg (2002)	Upper echelon theory argues that the composition, biases, values, and perceptions of top managers are important in creating an environment favorable to innovation. “It is expected that in high-discretion situations, chief executives will tend to be relatively young” ([26, p. 396]). CEO age is linked to risky strategies that favor innovation. Younger managers typically have less commitment to the status quo and adopt favorable attitudes toward a greater risk orientation that favor innovation. By virtue of their personal characteristics, managers will vary in the degree to which they develop and promote different types of innovation.	Attitude and age

assessment of potential technological alliances, 'differences in *noticing* may lead to perceptual differences as the decision-maker focuses less attention on certain stimuli while other stimuli dominate his or her attention. Perceptual differences due to *sense making* occur as the decision-maker frames the context of the decision, predicts possible outcomes, and forms causal attributions'. Thus, during the perceptual process, the potential exists for the executive's cognitive models or understandings to influence not only what information is noticed, but also the meaning attributed to that information. In their study on CEO values, organizational culture and firm outcomes, Berson et al. (2008), argue that 'self-direction involves an emphasis on making one's own choices, on free thought, and on learning, creating and exploring' and 'have been shown to guide individuals' *attention* and action towards intrinsically rewarding intellectual opportunities (Van Dijk and Kluger, 2004). Calantone et al. (1995) provided evidence that the 'degree of importance placed on an activity by the CEO affected the level of performance of that activity, as well as the ultimate financial performance of the firm'. These authors conclude that 'only by focusing top management *attention* on the importance of an activity will the discretionary effort occur to achieve the desired outcome'. In this study the concept of attention was defined as the degree of importance placed on a certain activity. Using longitudinal data over a period from 1990 to 2004, Yadav et al. (2007), in their study of CEO attention to the future, found that the level of focus of the CEO on the future and on the internal or external environment, as inferred from a psycholinguistic analysis of CEO's letters to shareholders, influenced the process of innovation. The level at which internet technology was used to develop internet banking systems and the breadth of the deployment of this technology were measured after a given period of tenure of the CEOs during which the detection, development and deployment of the internet banking system took place. The extent to which the CEO focused on future and external events – gave attention to these events - correlated with the speed of detection and development of the technology. The CEOs' attention to the future was a 'critical driver of innovation even when the target of innovation was not innovation per se but simply future events and external events in a generic sense or when the innovation outcomes occur far in the future (sometimes several years in the future)'. The authors propose an attentional explanation for why some top managers have a greater impact on innovation than others.

According to Yadav et al. 'scarce resource for many firms is no longer information; it is processing capacity to attend *to* information. Attention is the chief bottleneck in organizational activity, and the bottleneck becomes narrower and narrower as we move to the tops of organizations" (Simon 1973, p. 270)'. In addition, Yadav et al. argue that:

> 'Detection, development, and deployment require the awareness of external opportunities and the anticipation of future events. Therefore, CEO attention must have a temporal and a spatial component that increases such awareness. Combining these insights, we argue that the discretion CEOs exercise on temporal attention (e.g., emphasis on events that have yet to occur) and spatial attention (e.g. emphasis on events that have a locus outside the company) are predictive of firm innovation outcomes. When CEOs focus their

> attention on the future and on external entities, their communications and actions reflect this focus and serve to drive employees' attention to events and opportunities in the future and outside the firm. In turn, this leads to quicker detection by the firm of new technologies and technological opportunities. A greater attention to events in the future and to external objects also leads to greater preparedness for actions in the future, enabling quicker development and more extensive deployment of innovations based on these new technologies. In contrast, greater attention to internal objects leads to slower detection of new technologies, slower development of initial products based on these new technologies, and less extensive deployment of innovations.'

Also, what top managers pay attention to shapes how they decide and act (Cho and Hambrick 2006, Kaplan et al. 2003, Ocasio 1997). According to Eggers and Kaplan (2009):

> 'Technological change provides opportunities for incumbent firms to renew themselves, but these opportunities are generally fraught with uncertainty. Where information about the direction of change is ambiguous, it is not clear that the CEOs of all firms that stand to gain from the change would be aware of its potential. It is also possible that other factors competing for the CEO's limited attention may distract from the emerging opportunity. Under circumstances where the change would require substantial investments with risky payoffs, an understanding of CEO attention may help explain which firms would take advantage of this opportunity and when they would do so (Barr, 1998)'

In addition, Kaplan et al. (2003) showed that 'CEO attention to an emerging technology is associated with the subsequent investment in the development of such technical capabilities'. In other words, attention by the CEO is the prerequisite for a CEO to consider committing the firm's resources to the innovation. This means that CEO attention to the information available (in the marketplace or in the firm) will impact CEO attitude; thereby clearly distinguishing both concepts from each other.

Attention is defined as 'the noticing, encoding, interpreting and focusing of time and effort by organizational decisions makers' (Ocasio, 1997) and 'the time and effort that a CEO is willing to take to become informed about the potential opportunities that exist within and outside of the firm in view of future innovations (Yadav et al, 2007). The CEO looks for external and internal innovative ideas and for future opportunities and market-technology linkages. He/she sets the boundaries of the innovational project/work and the direction and the focus. Attention therefore, is a 'forward-looking' conception in that it collects data and information to bring the company into a next stage of growth. The 'forward looking' attribute to attention is used by Yadav et al. (2007) to determine the relationship between attention to the future and innovational output. If a CEO has a positive attitude towards innovation which results in a culture of innovation, and if

he/she has given attention to the environment (either internal and external) in order to identify opportunities for growth, he/she will need to decide whether the opportunities deserve investments. If the CEO argues that this is the case, he/she will become committed to the innovative project.

CEO commitment

According to Carbonell and Rodriguez (2009), 'managerial attention to building *supportive* governance systems and infrastructural *support* is a critical step in enhancing innovation speed'. This 'attentional' perspective is linked to the 'supportive' element of innovational activities in the firm. According to Carbonell and Rodriguez (2009), 'top management support refers to the amount of support given by top management to the NPD project'. Top management support can be made visible in a variety of ways: 'by acting as an executive sponsor, helping a team to surmount obstacles, providing encouragement to a team, maintaining open channels of communication with people involved in NPD, streamlining decision-making processes, and providing adequate capital and human resource' (Gupta and Wilemon, 1990; Smith and Reinertsen, 1992; cited by Carbonell and Rodriguez (2009) and 'by and large, existing research indicates that top management support plays a positive role in accelerating innovation speed' (Mabert et al., 1992; Emmanuelides, 1993; Kessler and Chakrabarti, 1996; cited by Carbonell and Rodriguez (2009).

The literature refers to a firm's commitment to innovation by referring to the level of R&D spending as a measure of the firm's commitment (Daellenbach et al., 1999). On the other hand, 'commitment' is also used to refer to leaders with 'vision, enthusiasm, future oriented external opportunities for inward investment and information gathering' (Laforet and Tann, 2006). The complex and long-range nature of technological innovation makes commitment particularly important to the R&D organization (Starling, 1991). Empirical research distinguishes between two dimensions of top management commitment: the (financial) support by top management and its positive attitude towards risk (Sanzo et al., 2012). According to Llorens et al. commitment means that top management fully supports innovation activities (Llorens et al., 2004: cited by Sanzo et al., 2012) by making available appropriate funds and resources for each innovation project (Cooper and Edgett, 2004; Swink, 2000; cited by Sanzo et al., 2012) *and* by accepting the risky nature of innovation projects (Menon et al., 1997; cited by Sanzo et al., 2012). The attitude towards risk – as discussed in the previous section therefore is linked to the concept of commitment. Top management that shows an unfavorable attitude towards risk, will not be inclined to offer valuable and scarce firm resources to innovation.

The NPD literature shows the key role of top management in new product success (Cooper and Edgett, 2994; Gupta and Willemon, 1990; Swink, 2000; cited by Sanzo et al., 2012). Performance of an NPD-strategy and of the elements that constitute this NPD strategy, such as customization, new product introduction, design innovation, product development cycle time, product technological innovation, product improvement, new product development, and original product development, are linked to the importance

assigned to that activity by the CEO. The relationship between a firm's performance on a specific NPD activity and the importance assigned to that activity by the firm's CEO drives the NPD strategy. The vision and focus on these NPD activities start with the recognition by the CEO of their strategic value and with the assignment of appropriate staff and technical resources to the performance of these activities, i.e. with the commitment of resources to each of them (Calantone et al., 1995). These activities ensure that the organization is sufficiently flexible to accept the changes in responsibilities for coordination and leadership that are necessary during different stages of the NPD process. In contrast with 'CEO attitude' which is a general positional stance towards innovation and with 'CEO attention' which is an 'explorative' concept in that the CEO looks for opportunities, CEO commitment takes the role of the CEO a step further in that he/she now is committing to the innovation by making available resources, either human or financial – for the innovation to take place. The impact of the support from top management (the full team as opposed to the CEO alone) on the speed of innovation had a more positive effect on innovation speed under conditions of high-technology novelty and high technological turbulence (Carbonell and Rodríguez-Escudero, 2009).

Lack of top management commitment seems to require effective cross-functional communication flows for New Product Development (NPD). Projects that received top management support were less likely to be terminated but did not necessarily develop in profit-makers for the company, suggesting that the choice of projects by top management is not effective (Green, 1995). In NPD, greater top management support was associated with better time-based performance of NPD projects; however, data suggest that higher levels of top management support in NPD were ineffective in securing good financial performance in high-technology environments (Swink, 2000). According to Green (Green, 1995), 'top management is enjoined to look at the needs and capabilities of the firm, the resource commitments represented by lines of research, and the commercial potential of projects and choose where to place their limited time and resources'.

Commitment therefore is 'the act of committing, or putting in charge, to entrust, to bind to a certain line of conduct' (Thatcher and McQueen, 1980). Commitment in the context of innovation can therefore be defined as: 'the willingness by the CEO to make human and financial resources available to conduct innovative projects in the firm, to develop processes that foster R&D output and to allow operational freedom in R&D in order for it to achieve its goals and to create incentives and reward's. Commitment therefore is a "facilitating" conception, in that it creates the specific circumstances for R&D to flourish, either by financial means, human resources, facilities, equipment etc.

CEO involvement

According to Elenkov et al. (2005), 'both theoretical discussions and empirical investigations have indicated that organizational acceptance and promotion of innovation require top management support and involvement (e.g., Drucker, 1985; and Hitt, 1999; Jassawalla and Sashittal, 2000; cited by Elenkov et al., 2005). The act of involvement is 'to connect by way of natural result or consequence, to blend' (Thatcher

and McQueen, 1980). This 'blending' is at the core of the concept of CEO involvement and presents the CEO as a participant in the innovative activities of the firm. It requires the CEO to take a step beyond the level of attitude (a positive stance towards innovation in general), attention (the collecting of information from internal and external sources to feed innovation) and commitment (the willingness to make available resources to innovation), as these roles may be played 'outside' of the innovation project, while the role of a CEO who becomes involved in innovation requires the blending of the CEO with the innovational activities, projects, discussions and understandings of the project and knowledge of the underlying technologies. According to Swink (2000), 'top managers should draw a note of caution regarding their close involvement in high technologically innovative development efforts' as the results of this and other studies 'suggest that top managers may sometimes do more harm than good' and they 'rarely influence product/market innovations directly because their involvement may be counterproductive if perceived as 'micro-management' (Elenkov and Manev, 2005).

On the one hand, it has been shown that there is relatively rare involvement of top management in specific projects (Markham et al., 1991; cited by Green, 1995), but on the other hand, in small, high-growth (packaging) design firms, CEOs were deeply involved in design decisions (Dickson et al., 1995). Although it is not clear whether this involvement leads to more successful products, the majority of the firms studied by Dickson et al. consider the involvement of their CEOs to be important and the CEOs argue that the knowledge base of their managers should be considerable, thereby linking involvement *in* a (design) project with the knowledge *of* the features of a design project. The CEOs' involvement in product/service design seems to be a significant predictor of investment in product/ service but it is not a significant predictor of the level of sales revenues generated by new products. The absence of such a relationship indicates that CEO involvement alone was not enough to guarantee financial success in new product development (Dickson et al., 1995). In the case of intranet adoption, CEO involvement appeared to be the only factor to have a significant impact (Al-Qirim, 2007b). Laforet and Tann observed that in more innovative companies the CEO was found to be much more involved in developing new products and ways of working than in less innovative companies. Such involvement was defined as 'innovation leadership'. In 75 percent of the cases of the more innovative companies, the CEO came across as the project-champion and was observed to evaluate new ideas for products, whereas the NPD team evaluated innovation processes.

In contrast with 'CEO commitment', a role concept that allows the CEO to invest in innovation by making available human and financial resources, the role conceptualization of 'CEO involvement' takes the CEO to the next level of engagement in innovation, i.e. by becoming part of the innovation project through the interaction with the innovators and discussing the innovation project. This requires an increased level of knowledge into the area that is subject of innovation, as was shown in the field of information technology (Bang et al., 2006): CEO involvement seems to be the key factor in the adoption of e-business by SMEs in Korea.

Green (1995) found evidence that top management is an active player in individual R&D projects. However, such involvement of top management 'may cross the line between support and become meddling, however, where they begin to micro-manage projects'. In Green's study, 'behaviors that might be seen as more meddling in character, i.e., exerting influence over project level decisions and monitoring project performance, were seen by R&D personnel as part of a larger support construct that included behaviors where top management took a role in informing and supporting the project. This finding suggests that even though top management might increase their control over the project that control was not seen as autocratic or meddling'. Thus, Green concludes: 'at least, it appears that when top management chose to be involved at the project level they were seen as adopting a shepherding posture in managing innovations'. There is no evidence in this study, however, that top management's involvement in specific R&D projects, resulted in picking 'winners' (Green, 1995). According to Papadakis and Bourantas (1998), in incremental product innovation the role of the CEO appears to be insignificant. Results suggest that technological innovation of this nature is accommodated within the existing departmental decision-making mechanisms, with minimal involvement of the CEO. Here, our data suggest that the main influence emerges from outside consultants and from changes in the external environment.

Involvement in the context of innovation is 'the engagement of the CEO to take part in the discussions and idea generation of new opportunities in R&D and which requires prior in depth knowledge about the R&D innovational project'. Involvement is a 'knowledge' conception as it requires prior expertise in the field of R&D in which the firm is engaged.

CEO innovativeness

The term 'innovativeness' appears in a number of papers discussing the role of the CEO in innovation. It is frequently used to describe the innovative character of an organization ('firm innovativeness' or 'corporate innovativeness') but it is rarely used to describe the innovative behavior of a CEO. Thong and Yap and Al-Qirim use the term CEO innovativeness (Thong and Yap, 1995; Al Qirim, 2007). Thong and Yap define CEO innovativeness as the characteristic of a CEO who is 'an entrepreneur figure who is crucial in determining the innovative attitude of a small business'. They add: 'This is because the CEO's qualities are the determinants of the overall management style of the business. In fact, the rate at which a small business changes depends not only on factors like business size or market forces, but also on the abilities and inclinations of the CEO and the extent to which he is able or prepared to devolve management. It is the role adopted by the CEO that determines the innovativeness of the business'. Thong and Yap illustrate CEO innovativeness as a CEO who has original ideas, would sooner create something new than improve something existing and who often risk doing things differently. In addition, they specifically distinguish between 'CEO attitude', 'CEO knowledge' and 'CEO innovativeness'. According to Thong and Yap, Kirton (1984) contended that 'everyone is located on a continuum ranging from an ability to do things better to an ability to do things differently … and … called the two extreme ends of the

continuum adaptors and innovators respectively. The adaptor CEO would seek solutions that have already been tried and understood. The innovator CEO would prefer solutions that change the structure in which the problem is embedded - in other words, solutions that have not been tried out and are therefore risky'.

In looking for reasons for slowness in adopting technological innovations in small and medium-sized enterprises, researchers looked, among organizational, technological and environmental factors, for the impact of entrepreneurial factors defined as CEO innovativeness and involvement (Al-Qirim, 2007b; Al-Qirim, 2007a). The data suggest that CEO innovativeness was the only significant factor in the adoption of technological innovations. This observation shows the importance of an innovative CEO as far as the adoption of innovations is concerned. As a result of the central role of the CEOs in SMEs and the impact of their innovativeness, it became clear that they were responsible for the introduction of new technology into their firms. In line with Thong and Yap (1995), CEO innovativeness is the characteristic of a CEO that 'makes him or her an entrepreneurial innovator in his/her own right, drives the product development program personally, takes control of the development detail and is trying to transform/disrupt the market with new products'. Innovativeness therefore is an 'entrepreneurial' conception, characterized by risk taking, perseverance and flexibility (Kitchell, 1997)'.

Overview of papers in which CEO role conceptualizations are used. The table below lists the research papers in which conceptualizations of the role of the CEO in innovation were used. These concepts are attitude (CEO attitude or 'CEO ATI'), attention (CEO attention or 'CEO ATT'), commitment (CEO commitment or 'CEO COM'), involvement (CEO involvement of 'CEO INV') and innovativeness (CEO innovativeness or 'CEO INN'). Not all papers address the concept of attitude with the same focus and depth. The impact of CEO attitude in public organizations for example was explored in detail by Damanpour and Schneider (2006) and weighed against environmental factors while others refer to attitude as an important factor in driving innovation without exploring the impact of the concept. Yadav et al. (2007) researched the attention given by the CEO to opportunities in the internal and external environment to investigate its impact on innovational output. Other authors such as Thong and Yap (1995) have used CEO attitude as well as CEO innovativeness, while Al-Qirim (2007) use CEO involvement and CEO innovativeness as independent variables in their research. Still other authors make reference to these concepts while not using them in their research project but emphasize their importance. Those papers that address the concept as the main topic in their research are identified by a '+' in the shaded cell in the table. For example, attitude of the CEO was specifically addressed by Damanpour and Schneider (2006), by Papadakis and Bourantas (1998) and by Thong and Yap (1995). Other papers that address attitude of the CEO towards innovation but do not research the concept, are only indicated by a '+' in the table cell. The table also presents the number of papers addressing the concept and the papers that only mention the concept (2 bottom rows).

Paper	**CEO**	**CEO**	**CEO**	**CEO**	**CEO**

	ATI	ATT	COM	INV	INN
Ettlie, J. E. (1990)	-	-	-	-	+
Bang, N. J., Kyeong, S. H. and Myung, J. L. (2006)	+	-	-	+	+
Al-Qirim, N. (2007)	-	-	-	+	+
Dickson, P., Schneier, W., Lawrence, P. and Hytry, R. (1995)	-	-	-	+	-
Laforet, S. and Tan, J. (2006)	-	-	+	+	-
Simsek, Z. (2007)	-	-	(1)	-	-
Datta, D. K. and Guthrie, J. P. (1994)	+	-	-	-	-
Calantone, R. J., Vickery, S. K. and Dröge, C. (1995)	-	+	+	-	-
Green, S. G. (1995)	-	-	+	+	-
Kitchell, S. (1997)	+	-	-	-	-
Young, G. J., Charns, M. P. and Shortell, S. M. (2001)	+	-	(1)		
Carbonell, P. and Rodríguez-Escudero, A. (2009)	-	+	+	-	-
Thong, J. Y. L. and Yap, C. S. (1995)	+	-	-	-	+
Tyler, B. B. and Steensma, H. K. S. (1998)	+	+	+	-	-
Daellenbach, U. S., McCarthy, A. M. and Schoenecker, T. S. (1999)	-	-	+	-	-
Damanpour, F. and Schneider, M. (2006)	+	-	+	-	-
Lefebvre, L. A., Mason, R. and Lefebvre, E. (1997)	+	-	+	-	-
Papadakis, V. and Bourantas, D. (1998)	+	-	-	+	-
Lynskey, M. J. (2004)	-	-	-	-	-
Yadav, M. S., Prabhu, J. C. and Chandy, R. K. (2007)	-	+	-	-	-
Berson, Y., Oreg, S. and Dvir, T. (2008)	-	+	-	-	-
Lefebvre, E. and Lefebvre, L. A. (1992)	+	-	-	-	-
Elenkov, D. S., Judge, W. and Wright, P. (2005)	-	-	-	-	-
Elenkov, D. S. and Manev, I. M. (2005)	-	-	-	+	-
Swink, M. (2000)	-	-	+	+	-
Wu, S., Levitas, E. and Priem, R. I. (2005)	-	-	-	-	-
DeTienne, D. R. and Koberg, C. S. (2002)	+	-	-	-	-
Eggers, J. and Kaplan, S. (2009)	-	+	-	-	-
Makri, M. and Scandura, T. A. (2010)	+	-	-	-	-
Number of papers addressing the concept:	12	9	8	11	4
Number of papers studying the concept (shaded)	3				

Appendix E. Procedure for the interviews of the CEOs

Seen the difficulty of approaching CEOs and obtaining their agreement to engage into academic research, it was decided to select the first two CEOs who agreed to collaborate as pilot cases. By coincidence, the CEOs had very different backgrounds. One of them had a long international career as CEO of life science R&D firms and was medically trained. The other one had a long career in business/finance and became CEO only recently. The reason why this is mentioned at this stage of our exploration is that in the literature, the CEO's educational and experiential background is used to explain the impact of the role of the CEOs on innovation. The following sections present the approaches followed, the findings, a discussion of the findings and a conclusion with respect to the findings and the interview methods. Finally, a comparative analysis is presented.

The first pilot case was conducted by means of an open, conversation-like interview with the objective to obtain a "feel" for the interview of a CEO and to gauge whether this approach would lead to interesting data on the role of the CEO in innovation and could be used for additional (final) exploratory work. An open-ended interview is based upon psycho-analytical theory, the content of which is free and non-directive and proceeds in an open manner constantly under the 'evenly-hovering' attention of the interviewer (Kvale and Brinkman, 2009). The question that opened the conversation was as follows:

> *'Have you ever, in your previous years, had the need to reflect upon your role as a CEO in research and development or innovation in general?'*

Starting from this question the interview proceeded without a specific direction to address an a priori concept but rather to obtain a good understanding of what the CEO considered to be his role in innovation in a life science R&D firm. The questions and answers were transcribed and checked for completeness. As it was possible to obtain interest from 15 CEOs of small-medium sized life science R&D firms, it was decided to initiate our research project with 2 pilot studies to obtain a 'feel' for these 'elite-interviews'. Therefore, the research project is divided into two subprojects: a pilot research project and a final research project. The following section presents the pilot research and includes the conclusions as well from a content point of view as from a methodological pint of view. Based upon the pilot research data and the selected methodology, we then discuss whether we can take this approach forward into the final research interviews.

According to Pettigrew (1990), 'given the limited number of cases which can actually be studied, it makes sense to choose cases such as extreme situations and polar types in which the process of interest is 'transparently observable''. Or, with Eisenhardt (1989): 'while the cases may be chosen randomly, random selection is neither necessary , nor even preferable'. In view of the comments made above with respect to the high degree of variation of innovational settings under which the role of the CEO was explored, and the potentially 'over-generalized' conclusions which were reached, the selection of

cases to conduct the research becomes particularly sensitive and important. Therefore, the basis upon which the cases were selected for this research need to be clearly put forward. The following inclusion criteria were used:

Inclusion criteria:

- The cases should be firms involved in life science R&D because it is important, as a researcher, to have knowledge and understanding of a specific innovational environment. As stated by Stebbins: "Field based research requires the researcher to have the right understanding of the environment in order to be able to ask the right questions" (Stebbins, 2001). It is hardly possible to try to understand the role of the CEO in a given industry – let alone in a group of different industrial environments – without an understanding of the nature of that industry and the challenges it faces.
- The firms should have a clear internalized R&D function headed by a director/VP R&D or a CSO. This is an important criterion, because in firms that conduct R&D and which are headed by CEOs who act as CSOs (which is often found in micro R&D firms and start-ups) the question about the role of the CEO is obsolete as he/she is taking up the role of innovator him/herself. Therefore, the decision was taken to explore the role of the CEO in innovation in an environment where the CEO has the discretion *not* to play that role.
- The selected firms have to be small and medium sized, in line with the EMA definition of SMEs. Their total workforce should be between 10 and 50 (small) and between 50 and 250 (medium). In these companies the role of the CEO may be more pronounced and better observable than in major corporations (Miller and Toulouse, 1986). The definition of SMEs is given by the European Commission Recommendation 2003/361/EC as follows:
    - The category of micro, small and medium-sized enterprises (SMEs) is made up of enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million.
    - Within the SME category, a *small* enterprise is defined as an enterprise which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 10 million.
- Cases were selected whereby the educational backgrounds of the CEOs differ. Companies should be led by CEOs with a science/medicines background or by CEOs with a strong finance/investor background, thereby maximizing differences between CEOs while maximizing similarities between firms. This case differentiation may lead to the observation that a priori conceptual roles identified in the literature occur in some firms while not appearing in others because CEOs with a scientific/medical background approach R&D through a different conceptual role.

The following exclusion criteria are used:

- the selected cases (firms) are such that the innovation is generated by internal research and development only. This criterion excludes firms that innovate by acquiring other (more innovational) firms and therefore exclude major pharmaceutical companies and hence the big-pharma firms
- *Micro* enterprise - defined as an enterprise which employs fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million – are also excluded

In order to select companies for our research, three databases were consulted :

- the MEDTRACK database: a worldwide database which allows the selection and description of companies in the life science industry
- the European Medicines Agency (EMA) database for the selection of life science based R&D SMEs in Europe
- the FlandersBio database for the selection of Flemish life science based R&D SMEs

The DATAMED database was consulted by means of the following search procedure:

Step	Action	Comment
1	Select industry hub	The industry selected was the life science R&D based family of companies
2	Select companies with a clear therapeutic category: "cancer drug R&D"	This subset was selected as there are many companies actually looking into the discovery and development of new drugs for the treatment of cancer (most life science R&D firms are engaged in cancer research as this is a potentially highly profitable market and because there are many different types of cancers each of them requiring different therapeutic approaches.
3	Select non-US public companies operating in Europe	In order for the research to proceed at a cost efficient level and to reduce costs of travel, companies were selected that have their HQ and laboratories located in the European continent
4	Download the excel sheet with the list of companies and their administrative data	By administrative data is meant: address, city, state, phone, website, contact and title
5	Select countries by means of the country filter	Country selection: Belgium, France, Switzerland, The Netherlands, UK, Denmark, Sweden, Norway, Austria, Finland, Ireland, Italy and Spain
7	Remove "Big Pharma"	Big Pharma was removed from our research (see exclusion criteria)
8	End result	R&D firms
9	Screen companies for: R&D spending, sales data, employees, R&D spending per employee and R&D comparison with industry average	
10	Download selected companies and print out overview	This excel sheet forms the basis for further manual selection of companies based upon number of employees
11	Remove all companies with less than 50 employees and more than 250 employees	A SME is a firm with more than 50 and less than 250 employees (definition of SME by the European Medicines Agency)
12	Select from the list of companies those companies with a clearly defined CSO position	See inclusion criteria
13	End result: 20 SMEs involved in cancer drug R&D	

If the MEDTRACK database was searched for non-cancer drug R&D companies, an additional three companies could be selected and they were added to the list of companies selected through the steps identified in the table above. The total number of companies selected through the MEDTRACK database is 20. Using the EMA research database a further attempt for company selection was carried out using the search

functionality of the EMA website (ww.ema.org). This did not result in additional companies. Using the FlandersBio database a search procedure was carried out using the search functionality of the Flanders Bio website (ww.flandersbio.org). This resulted in 5 new life science R&D companies that were approached. Additional life science R&D companies were approached through the existing CEO network in Flanders (Hertz and Imber, 1995). This resulted in an additional life science R&D company to join the program. The companies were first approached by means of an email message explaining the reason for the research project and how the outcome may prove useful for the CEO's management and the firm's innovative output. This was later followed-up with a phone-call to the CEO's secretary asking for a short introductory talk with the CEO. Most emails were not replied to but were then followed-up with a reminder email. One approach that proved useful was asking a CEO who had agreed to collaborate in the project to identify other CEOs, an approach which was also supported and proven useful by Hertz and Imber who studied elites (Hertz and Imber, 1995). Finally, 15 CEOs agreed to join the research project. The CEOs are listed in the table below.

Company	Company size	CEO age (yrs)	CEO gender	CEO nr	Country	Date interview
T	SME	>50	Male	CEO1 P	Belgium	February 17, 2012
A2	SME	>50	Male	CEO2 P	UK	February 23, 2012
C	SME	>50	Male	CEO1	Belgium	March 8, 2012
A1	SME	>50	Male	CEO2	Belgium	March 14, 2012
B	SME	40-50	Male	CEO3	Belgium	March 21, 2012
T	SME	40-50	Male	CEO4	Spain	March 27, 2012
A3	SME	40-50	Male	CEO5	Switzerland	April 12, 2012
A4	SME	40-50	Male	CEO6	Netherlands	April 20, 2012
C	SME	>50	Male	CEO7	Belgium	April 23, 2012
R	SME	40-50	Male	CEO8	Belgium	April 24, 2012
S	SME	40-50	Male	CEO9	Netherlands	May 4, 2012
O	SME	>50	Male	CEO10	France	April 23, 2012
J	Big pharma	>50	Male	CEO11	Belgium	October 4, 2012
G	Big pharma	40-50	Male	CEO12	Germany	July 12, 2012
O	SME	40-50	Male	CEO13	Belgium	November 26, 2012
A5	SME	40-50	Male	CEO14	Belgium	November 27, 2012
P	SME	30-40	Female	CEO15	Belgium	November 7, 2012

Preparing for the interview

In order to prepare for the interviews, a thorough understanding of the scholarly subject is required as well as the background knowledge of the fields and careers of the interviewees (Kvale and Brinkman, 2009). This is important for two reasons: it illustrates to the interviewee that the interviewer has a sincere interest in the management of these firms by showing knowledge about the previous experience accumulated by the CEO and the history of the firm. The information of the CEO is available through the company's website and therefore is an interesting source to become familiarized with the educational and experiential background of the CEO. In addition, before each visit, the annual reports of the companies (if available) were analyzed to understand the R&D pipeline and its successes and failures.

Operational procedure

According to Yin (Yin, 2009), 'this process of data collection (i.e. the case study approach) leads to the need to have explicit and well-planned field procedures'. The procedural approach for conducting this qualitative research is as follows.

Step	Action
1	After having obtained the agreement of the CEO to engage in this research project, send a "thank you" letter (see Appendix)
2	Arrange with the CEO's secretary to find an appropriate date for a interview meeting within a three months time frame (agree for approx. 1,5 hr meeting time)
3	Once a date is set, send a letter to the secretary with a detailed modus operandi for the meeting and the broader context under which the meeting will take place. More specifically, include in the letter: - Confirmation of the day and time - The fact that: o the interview will be recorded and transcribed o all data will be anonymized o a copy of the anonymized transcript will be returned o the results of the qualitative study will be made available to all CEOs
4	Three days before the interview, check the recording equipment, assure sufficient power, make yourself fully accustomed to the use.
5	The day of the interview: collect all materials: paper/pencil, recording equipment, an example of the literature review as a gift to the CEO.
6	Upon entering the executive office, offer the secretary a sincere thank you for the arrangement of the interview
7	Before the interview: - ask the CEO for agreement of the recording, stressing anonymity. - Explain how the interview fits into the research project and explain the next steps: o Treatment of the interview data o The goal of the data to develop working hypotheses o The involvement of the R&D function - Stress the fact that this research will help the firm to become more effective in R&D by informing the CEO about the needs of the R&D function from a CEO point of view to improve their output - Send a package to the CEO informing him/her about the approach that will be taken
8	Conduct the interview
9	After the interview, ask the CEO to appoint an individual (HR or COO or CSO or another individual appointed by the CEO) to continue the next research project in the R&D group
10	Two days after the interview, send: - a 'thank you" letter to the CEO confirming that we appreciate that we can continue our research together with his/her R&D team stressing that we will offer feedback on the data and inform him/her of further developments - a 'thank you"-email to the secretary informing her about the outcome of the interview
11	Conduct template analysis

IRB approval and informed consent

The study was approved under the Cranfield's School of Management ethical approval procedure. All CEOs agreed to sign an informed consent form, formally stating the volunteerism in participating in the study.

Interview recording, transcription and transcription checks

The interviews are recorded (Olympus LS11) and subsequently transcribed and submitted to template analysis. Each interview was transcribed immediately after each interview and was checked carefully for a correct transcription. This was repeated several times until it was assured that each sentence, phrase or question was transcribed correctly. A final check consisted of going through the tape while reading the text and the transcription was considered finalized only if there was full synchronization between the spoken words, phrases and questions and the transcription. In general this took 3 to 4 times until the transcription was finalized.

Triangulation

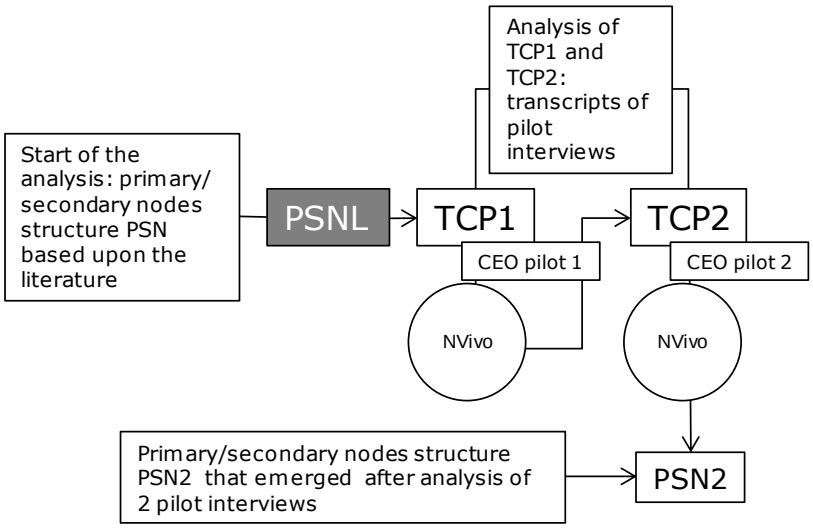
According to Patton, there are different triangulation approaches (Patton, 2002): triangulation of data (data triangulation), among different evaluators (evaluator triangulation), of perspectives to the same data set (theory triangulation) and of methods (methodological triangulation). Stebbins argues, taking the explorer's point of view, that 'both qualitative and quantitative data may be gathered during exploration'. In other words, although in most exploratory studies, qualitative data predominate, they are augmented where possible and desirable with such descriptive statistics as indexes, percentages and frequency distributions' (Stebbins, 2001, p6) and from a viewpoint of the validity of exploratory research results: 'exploration validity is…resolved… by using different methods to examine the same group or activity (known as triangulation), asking key informants to comment on the familiarity and reasonableness of observations, and finding recurrent evidence for each generalization' (Stebbins, 2001, p26). The provision of multiple evidence or triangulation will be increasingly important, the more critical the assertions that will be made (Partington, 2003, p. 125). In our case, triangulation would include the collection of documentary evidence such as meeting minutes, agendas, personal notes and comments and other data besides the interview. However, at the start of the interview it was not clear whether the CEOs who already agreed to accept an interview and a subsequent survey in their R&D units (and by accepting this have shown their willingness to commit themselves and their firms to this research project), would also accept the collection of documentary evidence such as personal agendas, meeting minutes etc. It was decided not to jeopardize the recruitment of the CEOs by asking them to make their agendas and meeting minutes available on top of their commitment and run the risk of having them refrain from participation because of an inappropriate request (at least from their point of view). As is known, CEOs are considerably difficult to recruit for this type of research (Yadav et al., 2007). It was therefore decided to let the decision to ask for these documentary data depend on the personal interaction that developed during the interview. The conclusions of each transcript were shared with the interviewed CEOs to assess the correctness of the interpretation because exploratory researchers should increase the validity of their research by discussing the generalizations with the people they are investigating to determine if these ideas 'have a familiar ring'. In other words, that they are considered plausible in the eyes of the respondents (Stebbin, 2001, p48).

Categories and text analysis

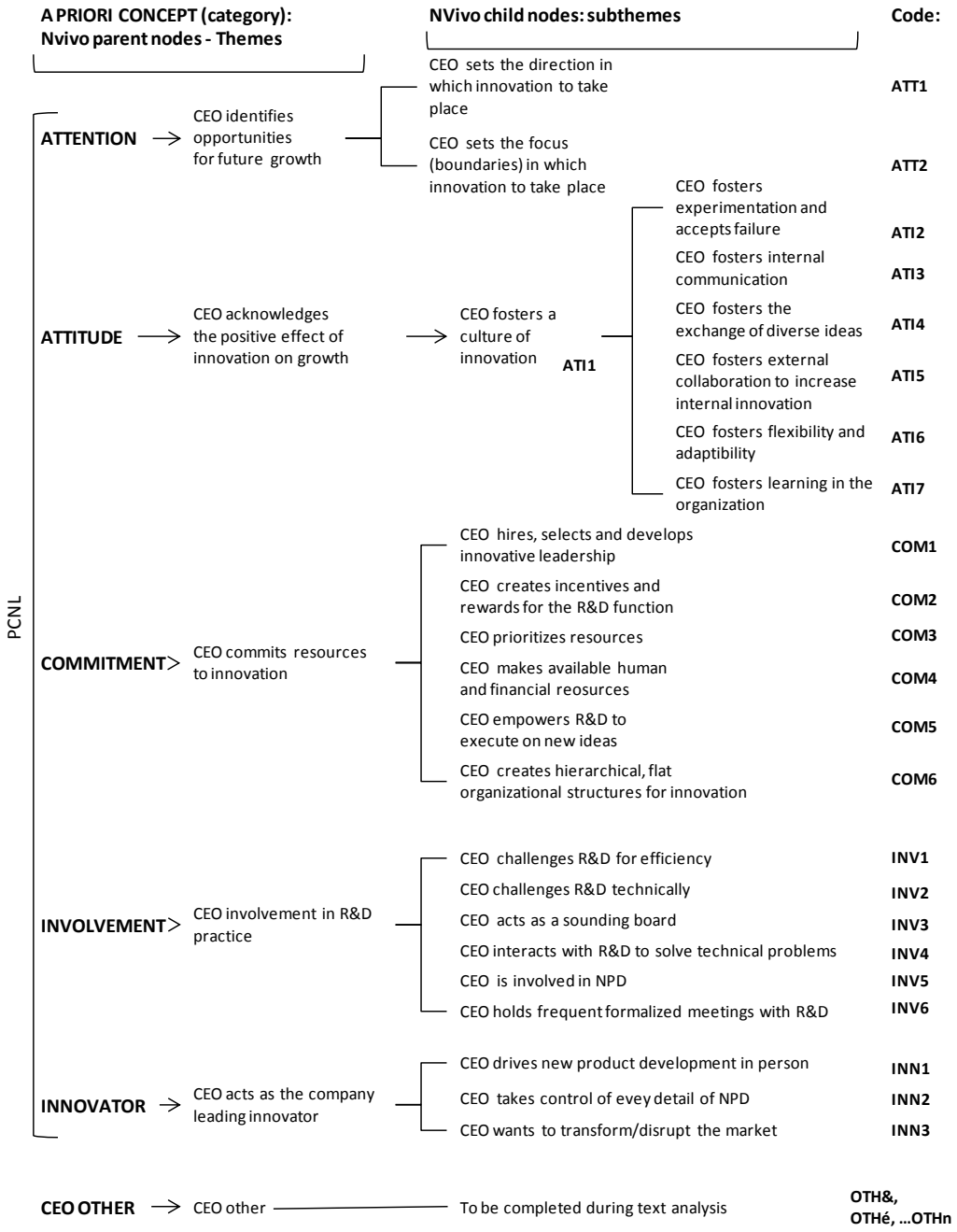
According to Kvale and Brinkman 'categorization is a form of coding whereby the meaning of long interviews is reduced to a few simple categories. The categories can be developed in advance or they can arise ad hoc during the analysis; they may be taken from theory, or from the vernacular, as well as from the interviewee's own idioms' (Kvale and Brinkmann, 2009, p203). In addition, categorization can provide an overview of large amounts of transcripts and facilitate comparison and hypothesis testing. In this research project, categorization is performed through the use of concepts which were retrieved from the literature. These concepts form the basis upon which interviews were analyzed. Each interview is transcribed and analyzed by means of NVivo software whereby statements, opinions, arguments (I.e. "quotes") made by the CEO are assigned to these concepts thereby allowing categorization to take place. The a priori concepts are defined as primary nodes in the NVivo software. To each primary node, a number of

secondary nodes was assigned. These secondary nodes act as a starting point for the NVivo analysis. An overview of the primary/secondary node (PSN) structure which was introduced in NVivo before the start of the text analysis is presented below. Each secondary note is codified by means of a code (ATT1, ATT2, ATI1 .... INN3) for future data retrieval and analysis. Statements, opinions and arguments which were raised by the CEOs during the interviews (i.e. the "quotes" made by the CEO) were assigned to a specific primary or secondary node. For example, the quote "I want to make sure diverse ideas are shared" is assigned to the secondary note ATI3 "CEO fosters the exchange of ideas". To the primary/secondary node structure an additional primary node (or category) was added which was entitled: "CEO other". This primary node "CEO other" was used to collect quotes that could not be assigned to the primary nodes attitude, attention, commitment, involvement and innovator or to any of the secondary nodes. These quotes are codified as 'CEO-OTH1, CEO-OTH2 … CEO-OTHn' etc and abbreviated as 'OTH1, OTH2... OTHn'.

Data collection: NVivo analysis of the pilot interviews. Using the primary/secondary node structure presented below, the transcript of the first pilot interview (TCP1) was analyzed. The quotes made by the CEO were assigned to the secondary nodes. As a result of the analysis, a new primary/secondary node structure, PSN1 was developed that included new categories assigned to the primary node "CEO other". This new primary/secondary node structure PSN1 (that includes the primary/secondary nodes linked to the a priori concepts and the new themes assigned to the primary node "CEO other") was subsequently used for the analysis of the second pilot interview transcript (TCP2). This transcript analysis leads to a new primary/secondary node structure PSN2. A schematic representation of this approach is presented in the figure below. The primary/secondary node structure PSN2 was then used to analyze the transcripts of the final interview transcripts (TCF1, TCF2 etc.), see below).



Starting concepts and themes pilot interview 1



Data presentation and discussion. After NVivo analysis, the number of quotes obtained for each secondary node were added for each category: CEO attitude, CEO attention, CEO commitment, CEO involvement, CEO innovation and CEO other roles. For example, if the number of quotes obtained for 'CEO sets the direction in which innovation to take place (ATT1)" is 7 and the number of quotes obtained for "CEO sets the focus(boundaries) in which innovation to take place (ATT2)" is 4, then the number of quotes for 'CEO attention (ATT)' is 11. This approach was used for 2 pilot interviews and 15 final interviews.

Quoting respondents

According to Stebbins (2001, p45), 'interviewee testimonials play only an illustrative role in ... exploratory research, it follows that exact quotations of them are by no means always necessary in such work. Because, most of the time, the respondents quoted are not personally identified, verbatim accuracy is, in reality unimportant. As long as it illustrates the generalization and conveys what the respondent meant to say, the quotation can, in fact, be a paraphrase of his or her original statement'. The transcripts of the interviews in this study were accurately transcribed in order to catch the reality of the situation; the hesitations and sometimes long periods of silence were therefore included in the transcript. The reproduction of the quotes in this report are not verbatim, but are used to illustrate the message of the CEO without deviating from the original statement.

Pilot interview of CEO1

Pilot interview findings pilot interview CEO1

The data obtained from the text analysis are presented in a bar chart below. It presents the number of times a theme emerges from the interview. New themes also emerged from the interview that could not be assigned to any of the major of subthemes. It is clear from this graph that CEO attention (ATT) and CEO commitment (COM) are frequently mentioned during the interview. CEO attitude (ATI) and CEO involvement (INV) are less frequently mentioned, while CEO innovator (INN), the concept that refers to the CEO as the leading innovator in the firm, is not mentioned. The individual subthemes are also introduced in the chart, together with the new themes that emerged from the interview. The table below presents an overview of new themes.

Theme (codified)	**Theme (statement)**
COM 7	CEO reduces development risk by hiring expert people
CEO-OTH1	CEO admits limited knowledge in a specific R&D area
CEO-OTH2	CEO admits not driving innovation but rather the direction of innovation
CEO-OTH3	CEO interacts with R&D only in those matters he/she has personal knowledge in
CEO-OTH4	CEO should not focus on technology
CEO-OTH5	CEO stresses the importance of strong knowledge in the field of innovation
CEO-OTH6	CEO takes strategic decisions based on simplified data
CEO-OTH7	CEO wants R&D to step out of academic thinking
CEO-OTH8	CEO role model is knowledge based

New themes emerging from the first pilot interview

The majority of the statements by the CEO are assignable to the concept of attention and more specifically to the theme "CEO sets the direction in which innovation to take place" (ATT1) and to the theme of "focus": "The CEO sets the focus (boundaries) in which innovation to take place" (ATT2). The CEO of this firm considers external collaboration to be important for innovation to take place (ATI5), the hiring, selection

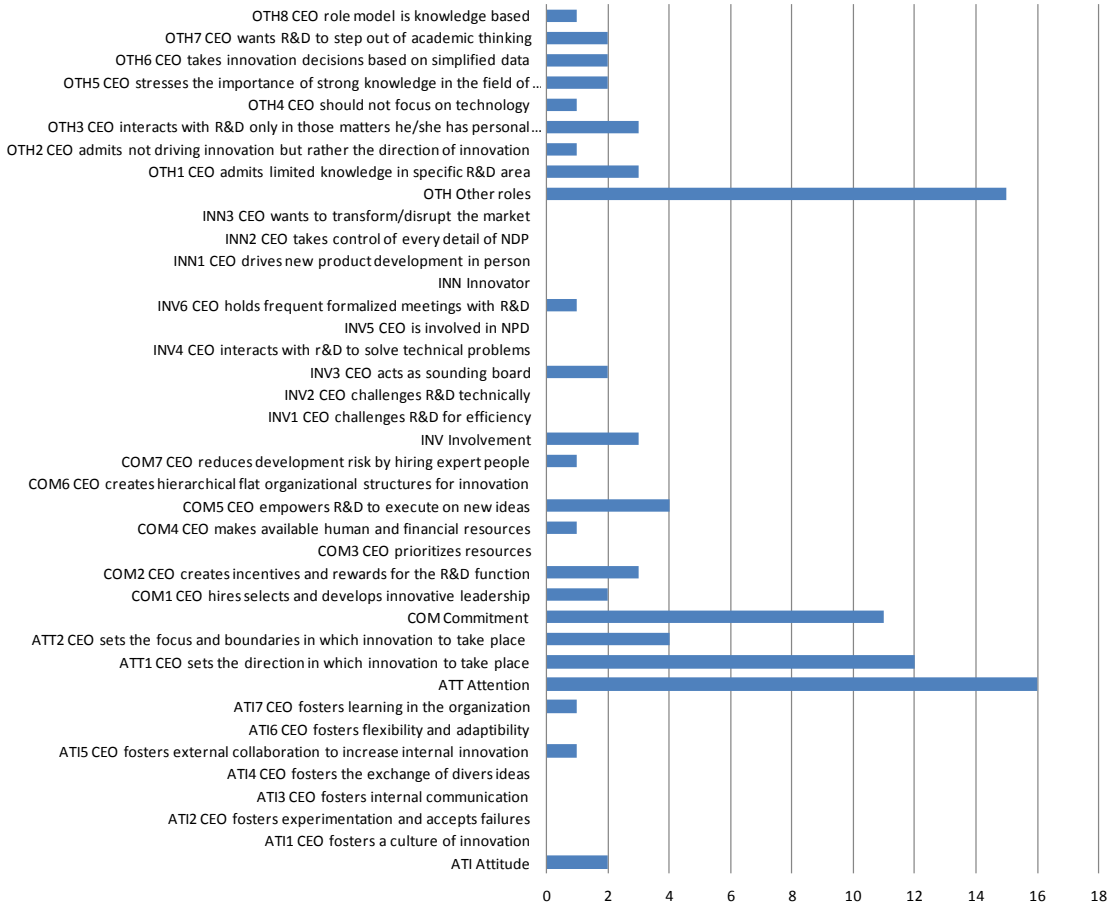
and development of innovative leadership (COM1) as well as the rewarding of top scientists (COM2). Empowerment of the R&D function (COM5) is another important innovation driving factor. This CEO attempts to reduce the risk of the firm's R&D by expanding the scientist pool in the company. This is a serious commitment on the part of the CEO and it was therefore assigned to the concept of commitment as an additional conceptual theme (COM7). Besides the a priori concepts, a number of new roles appeared that are either linked to CEO knowledge (OTH1, 3 and 5) and to the fact that the CEO stresses that he does not drive innovation but rather direction of the innovation (OTH2). The CEO argues that focus should be directed to the market and not to the opportunities that the firms' research may bring to the academic field of expertise (OTH7) neither to the available technology (OTH4). Finally, the CEO argues that strategic decision making should be a "simple process" ('it is not rocket science').

Discussion pilot interview CEO1

It became clear that the CEO stressed the importance of the need for a direction in which the company needs to develop its R&D projects and on focusing on the selected objective:

> *' ...what I do drive is the direction...where I want innovation to happen..'*
>
> *' I am not driving innovation, I am driving the direction of innovation*'

During the interview the CEO stressed repeatedly that his main responsibility is the setting of the direction (in this case a specific therapeutic area) and, within this specific therapeutic area, to focus on a specific disease condition. It was made clear by the CEO that this strategic R&D orientation cannot be made by the R&D function as it lacks an important strategic information source which is the link between available R&D capabilities in the firm and the market (medical) need. This notion of a "market-R&D linkage" is an important parameter that drives his strategy. This strategic decision making (direction, focus, orientation) is not about the future of the research or an academic objective that can be achieved but about the future of the company, the markets it will serve and the medical needs it will meet. There is, according to the CEO, a continuous tension between the CEO's strategy and vision and the R&D function whereby the latter should be controlled as not 'to lose itself' in academic objectives. The R&D function and its leadership should therefore be continuously be pulled into alignment with this vision. What is needed according to this CEO is a vision of the future, and thereby clearly refers to the literature concept of "attention to the future" as proposed by Yadav et al. (2007).



Themes from the first pilot CEO interview

The analysis resulted in the identification of a number of quotes and statements which are reflective of the CEO's commitment to innovation. This is illustrated by his conviction that outstanding scientists should be rewarded but that a reward system by means of financial incentives alone is not sufficient for the R&D function:

'How do we reward them? It's by giving them their freedom"

It is also illustrated by his commitment to make additional human resources available to the R&D function, not only to make R&D successful but also to minimize risk. By making available resources for the conduct of innovative R&D projects, risk reduction can be achieved though the availability of expertise and functional support in middle-management (defined by the CEO as the "second row"). During the interview, the CEO did not refer to the capital intensive nature of life science R&D, very likely because he considers this as a fact of life in life science R&D firms. The need for effective innovative human resources (' creative out of the box thinkers') was considered a top priority. The CEO referred to the fact that he empowers the R&D function and is not willing to control it's activities as long as the direction of innovation is clear. This empowerment of R&D is also caused by the fact that the CEO recognizes that his knowledge in the day-to-day

R&D activities is too limited to direct R&D lab activities or to become engaged in technical discussions. The CEO argues that there is frequent interaction with the R&D function but that this interaction is not driven by his expertise in laboratory experiments. However, the notion of involvement by the CEO in innovative activities was strong in that knowledge was considered an important CEO asset. The CEO referred to his innovation-relevant knowledge as bimodal. First, the CEO possesses knowledge common to two subgroups in R&D: clinical science and intellectual property. These are the two fields of expertise in which the CEO interacts (is capable to interact) with the R&D function, 'because that's what I understand'. Beyond this knowledge base of clinical science and IP, the CEO's knowledge base is too limited to interact with and contribute to other disciplines in R&D such as laboratory research. In other words, the CEO only interacts with those R&D groups that have a knowledge base shared by the CEO and is involved in R&D only to the extent that he has knowledge about specific topics in R&D. Therefore, the CEO stated that it is not he who drives innovation but rather takes the strategic direction in which to move the R&D function's activities:

' ... and that is why I don't drive innovation...'

Second, the CEO has expertise knowledge of the market which is needed to make the market-R&D linkage and to address medical needs. This knowledge can be defined as knowledge about the competitors and their R&D projects. This CEO also referred to the 'technology trap' in that CEOs 'may fall in love' with their technology and may risk losing track of the market potential that lies outside of the technology track. This is corroborated by the CEO's statement that the scientific activities in the firm should serve a market, not academic knowledge. When asked whether he has a role model in this regard, he referred to previous CEOs with whom he worked during the earlier periods of his career whereby the CEO to whom he reported was - and still is- known by his extensive knowledge about the market (need) and the R&D projects running at his own and at other firms. This 'knowledge' - considered to be an important factor that drives the role of the CEO in innovation - is a strategic knowledge base that allows the CEO to take decisions and point to the direction in which innovation needs to be steered. This is different from the knowledge which was defined in the literature - specifically in IT firms - where the knowledge base is specific knowledge that resides within the R&D function (Dickson et al., 1995; Laforet & Tann, 2006; Bang et al. 2006; Thong and Yap, 1995). The notion of knowledge that links market need to technology is crucial, and he clearly showed great respect and even awe for his role-model-CEO who 'knows':

> *'this guy knows a lot, ... he knows a lot (stresses: " a lot") ... and that's why management at (name of the firm) knows a lot, because it's embarrassing your chairman knows more than you..., ... he knows, he does know... I recently spoke to him .... and the guy knows, he knows the projects ... we talked on one of our projects .. he knew... I think is very important in life sciences in my opinion..."*

This notion of knowledge is not simple market know how (which the CEO stated you can 'simply buy') but knowledge that links both the internal know-how and R&D to meet medical needs.

Although attitude towards innovation can have very different themes ranging from the general concept of creating a culture of innovation to fostering learning in the organization, this CEO considers external collaboration to be crucial for two reasons. It elevates the internal know how by exposing the firm's R&D to outside expertise and it motivates the R&D function. The CEO stated that innovation cannot be sustained when it takes place within the boundaries of the firm: innovation can only be of value when it transgresses the firm boundaries and if it promotes collaboration, exchange of know-how with the outside world and organizational learning. The concepts of experimentation and failure acceptance, flexibility and adaptability, and exchange of ideas did not emerge during the conversation. This may be explained by the fact that the CEO considers these attitudes to be obvious in life science R&D firms that it is not worthwhile to draw attention to them. This may explain why the concept of attitude does not surface during the conversation. Any indication of entrepreneurial innovativeness with this CEO was not identified in this case. The CEO did not indicate that he is the (sole) driver of innovation in the firm, is developing products that will transform or disrupt the market or is taking control of every detail of the new product development.

There are a number of themes that appeared during this interview and which are considered "new" because they do not fit into any of the a priori concepts. Some of them have been discussed above such as the technology trap, the limited knowledge of all aspects of and interaction with R&D, the fact that he does not drive innovation but the direction of innovation and the topic of personal scientific and market knowledge. The CEO argues that strategic decision making should be simple (OTH6) in that the link between the available internal R&D know-how and the medical (market) need should not be considered "rocket science" and that "you do not need a lot of research documents to make a decision". This infers that the CEO takes strategic decisions based upon a number of simple and clear R&D arguments and links these to medical need upon advice from outside parties.

Interview observations pilot interview CEO1

The following preliminary observations can be drawn from this first pilot study:

- the CEO's knowledge about the innovation in his firm is situated in specific areas and it is only in these areas that the CEO interacts with R&D and engages in technical discussions
- in the other areas of R&D where the CEO has only limited or no knowledge, he interacts with R&D but does not engage in technical discussions
- the CEO's knowledge consists of a thorough understanding of the linkage between R&D capabilities and the market/medical need,

- the CEO takes strategic decisions which are reduced to the essentials so that it does not become a 'rocket science' .
- the CEO takes a healthy distance from available technologies in the firm to avoid become entangled in its promises rather than in its applicability
- the CEO minimizes project risk by extending the number of people associated with R&D

Although these observations are preliminary and can hardly be generalized, there are interesting to keep in mind for the final interviews. At this stage of our research it is important to evaluate whether the methodological approach that was taken, is acceptable for future interviews. This is discussed in the following section.

Criticism on the interview method pilot interview CEO1

Although the interview style used during the first pilot interview showed interesting conclusions, (which should be treated carefully seen the singularity of this interview), it is clear that a potential comparison (or contrasting) of the CEO's outputs with the output of other CEOs would potentially prove to be difficult as the variations in content could be high and therefore difficult to include in a comparative study. There are also other concerns with this approach. First, it consisted of open questions that led the CEO to enter the field of personal experiences of sometimes irrelevant topics such as the description of a personnel issue and the uncomfortable situation that was created. As only 60 minutes of interview time is available it is imperative that it is used efficiently without reducing the potential richness of the stories told by the CEOs. The question should therefore be asked whether the open conversation interview is the most appropriate use of the researcher's and the interviewee's time. Second, in her study of Nobel laureates, Zuckermann (Zuckerman, 1972, referenced in Kvale and Brinkman, 2001) argue that her background knowledge of the laureates' fields and careers legitimized spending the time for the interview but also required the 'necessity of her being very precise in her questions to this intellectual elite'. She argued that this was an important contributing factor in the success of her study. Therefore, the approach that was taken in this first pilot interview was reexamined and the open interview was redesigned into a focused interview consisting of precise questions. It was therefore decided to develop a number of to-the-point questions for the second pilot interview.

Pilot interview of CEO2

It was observed during the first interview that a conversation-like interview on the role of the CEO in innovation was not an approach that could be sustained for our final research. It was therefore decided to develop precise questions as will be discussed.

Interview questions pilot interview CEO2

The objective of the interview approach for this second pilot interview is to obtain improved control of the proceedings of the interview in order to obtain as much information as possible during a 60 minute time period while allowing further investigation of the concepts or themes that the CEO develops. As was stated above, in the case of elite interviews, the need for precise questioning is important as well as the

assurance that the interviewee understands that the interviewer has sufficient knowledge on the topic to be able to become a partner in the conversation. In other words, by asking precise questions, based upon prior knowledge of the firm, the technology and the overall life science R&D context, the interviewed CEO should find the interview an intellectually stimulating event. It was assumed that when this objective is realized, a stimulating conversation will result that allows rich data to be generated.
Precise questions were developed along four major approaches:

- a general approach in which the CEO is asked about his personal view on the (attributes of) the role and leadership of CEOs in innovation (questions 1 and 2),
- a specific approach in which it is explored how the CEO is engaged in R&D either through investment decisions, interaction (intensity) with R&D and through the exploration of the CEO's view on his/her role versus the role of the chief scientist (question 3 to 11) and on
- the attributes of an "ideal" CEO in innovation (question 12).

The following 12 questions were developed.

1. A question addressing the CEO's personal vision on the role of the CEO in innovation:
   What do you think are the attributes of the role of a CEO in a life science R&D firm?

2. A question on what the CEO considers important leadership characteristics in innovation:
   What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm?

3. A question gauging the commitment of the CEO in innovation:
   What are your driving factors to invest in, make available resources and support R&D?

4. A question on the relationship with R&D and the potential knowledge gap:
   How do you bridge the gap between the scientific/ biomedical knowledge in R&D and your general management's knowledge?

5. An open question stressing the role of the CEO vs the role of the CSO:
   How do you describe your role as CEO in R&D vs the role of your CSO?

6. A question on how the CEO may drive innovation personally:
   How do you as a CEO actually increase the output of R&D?

7. A question on involvement of the CEO in R&D discussions:
   How much time and effort do you make available to obtain information from your R&D team in percentage?

8. A question on involvement of the CEO in R&D discussions:
   How many times per week or month do you interact with R&D?

9. A question to gauge the knowledge base of the CEO in the interaction with the R&D function:
   During those interaction, what is the topic of discussion?

10. A question to understand the importance the CEO attaches to multilevel exchanges:
    With whom do you interact with R&D?

11. A question about the willingness of the CEO to engage in R&D discussions:
    Are those interactions ad-hoc or formally planned?

12. A question about the role model of the CEO to inquire about the ideal situation he/she looks upon as efficient innovation driving:
    Have you seen CEOs who were particularly effective in driving R&D, and why do you think they are?

As the interview period is limited to 60 minutes, an average of 2 minutes response time per question is available. However, the interviewer was not limited by this restriction and delved into more detail when a topic of interest was addressed. When the CEO answered the question, 'second questions' (Kvale and Brinkman, 2009) were asked to obtain a better understanding of the answer or to request more detail or explanation.

Findings pilot interview CEO2

The data obtained from the content analysis are presented in a chart below. On the one hand, it was found that the CEO rarely refers to the theme of 'attitude', such as fostering a culture of innovation as only 3 quotes in the transcript referred to the theme of attitude. On the other hand, 7 quotes referred to CEO attention, 8 to CEO commitment, none to CEO involvement and CEO innovator. However, 21 themes emerged from the interview that could not be assigned to any of the previous themes and were therefore coded as 'OTHx' in the chart below. It is clear from this chart that CEO attention and CEO commitment are recurring items during the discussion. CEO involvement in R&D practice describing the actual interaction between CEO and the R&D function is absent. The theme of 'CEO innovator' is not mentioned. Some of the 8 themes that emerged during the first interview were also identified in this interview (i.e. CEO-OTH1, CEO-OTH2, CEO-OTH4, CEO-OTH6 and CEO-OTH7) together with a set of new themes identified as CEO-OTH9, CEO-OTH10, CEO-OTH11, CEO-OTH12, CEO-OTH13, CEO-OTH14, CEO-OTH15 and CEO-OTH16. Although it is clear from the chart that the CEO considers the setting of direction/focus (ATT1 and ATT2), the commitment to look for financial resources to continue R&D (COM3) and the prioritization of the resources (COM4) as important aspects of his role, a majority of

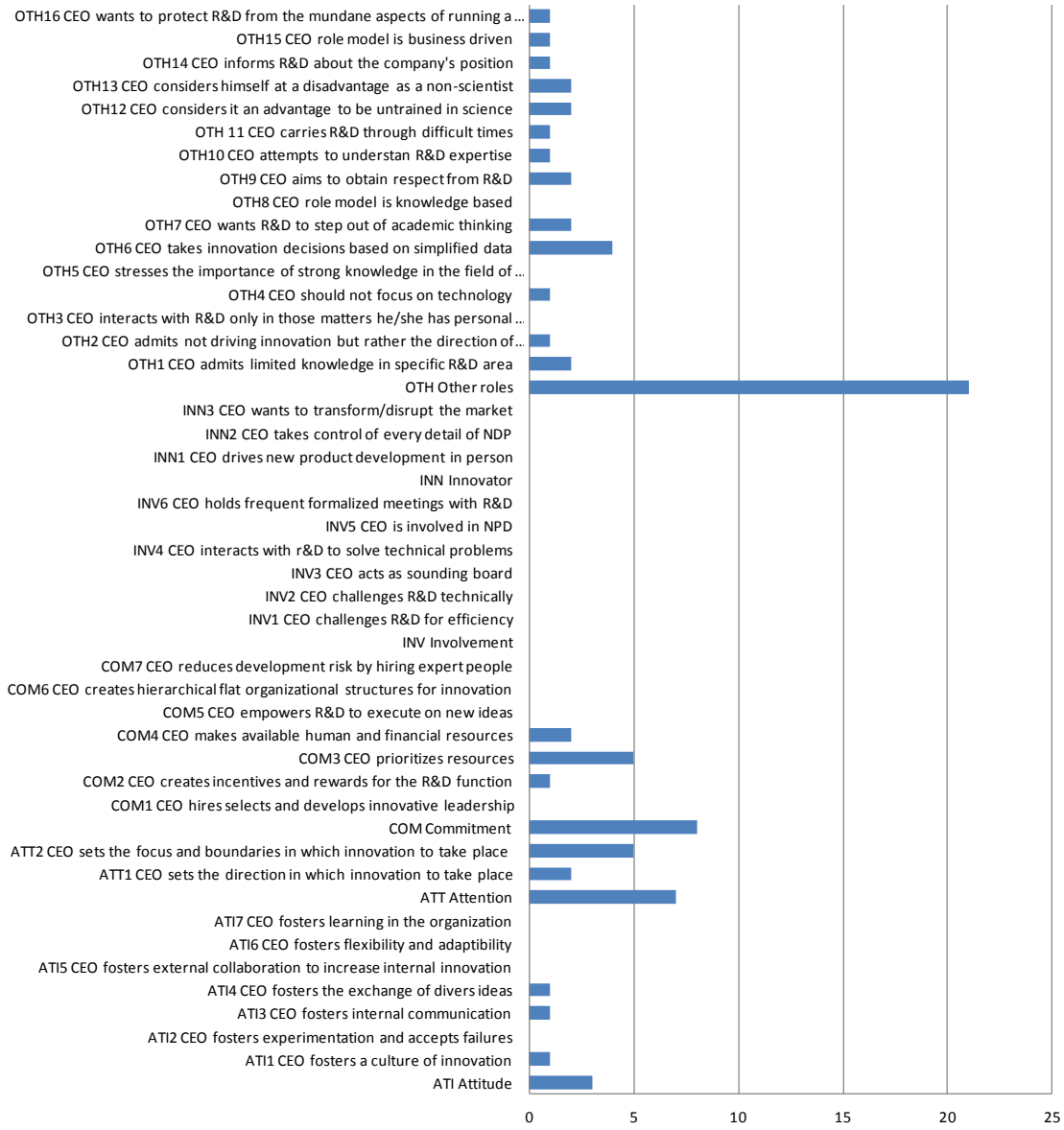
statements cannot be assigned to an a priori concept. As this CEO has a purely financial/business background he encounters difficulties to grasp the intricacies of R&D (CEO-OTH13) but on the other hand considers it an advantage to be untrained as a scientist (CEO-OTH12). The CEO makes the point that his major role is to assure sufficient financial means and that he wants to protect R&D from the more mundane aspects of running a life science R&D firm that is continuously looking for additional financial means (CEO-OTH11 and CEO-OTH17). This makes the CEO argue that he deserves respect from R&D - although he cannot interact nor contribute to their work - because his contribution lies in the fact that he is supporting R&D financially and adds value to their work by looking for commercial value (CEO-OTH9).

Discussion pilot interview CEO2

While the previous CEO decided to hire innovative individuals as a source of creating innovation and reducing risk, this CEO argued that the climate of innovation should be nurtured by making available sufficient financial resources to conduct R&D, stating that if there are sufficient resources, the innovational culture will be generated automatically and flourish. Whether this approach is driven by the fact that this CEO has a pure business background with no previous exposure to scientific and/or medical activities is a matter of speculation. It was clear that attention to drivers of innovational culture in this firm such as open communication, exchange of ideas, interaction with external partners was poor. The role of the CEO in innovation on the other hand was clearly related to the 'setting of a direction' and to 'confine' these activities towards the company's goals. When asked what was meant by 'setting direction' of R&D and how he - a CEO with a strong financial background – sets the direction of R&D, the CEO apologized for having used the term 'direct' and corrected himself by stating that the setting of the direction in fact is a combined effort in which the scientific expertise in the company and his financial expertise allows the setting of boundaries in which the research can take place:

> *'I don't direct ... I put up a set of rules within which we have to operate and using the scientific resources and some of my own knowledge we arrive at where we should spending money ..*

The topic of R&D knowledge – or absence of it - came to the surface during the discussion and two points of view surfaced. On the one hand, the CEO clearly considers his financial expertise a positive factor in the management of a R&D company but realizes that his absence of scientific knowledge on the research topics which were required to run this type of company has been a 'very humbling experience'. He admits that he does not have good insight into the R&D work that is carried out in the company. On the other hand, the need to rely on the scientific expertise of his CSO has a major advantage – at least from his point of view - in that he does not have to 'second-guess' the CSO's decisions seen the expertise and reputation of the latter.



Themes from the second pilot CEO interview

Theme (codified)	Theme (statement)
CEO-OTH9	CEO aims to obtain respect from R&D
CEO-OTH10	CEO attempts to understand R&D
CEO-OTH11	CEO carries the scientists and their R&D through difficult times
CEO-OTH12	CEO considers it an advantage to be untrained as a scientist
CEO-OTH13	CEO considers himself at a disadvantage as a non-scientist
CEO-OTH14	CEO informs R&D about the company's position
CEO-OTH15	CEO role model is business driven
CEO-OTH16	CEO wants to protect R&D from the mundane aspects of running a firm

New themes emerging from the second pilot interview

This, according to the CEO, is an advantage of a non-science CEO. However, this knowledge factor has another implication. In order for the CEO to make strategic decisions, he requires the presence of an individual ('X') besides the CSO who is capable of translating the expertise knowledge into a market environment. In other words, the complex data that are being brought to him by the scientific elite in his company requires translation into the strategic arena by an individual who is capable of recreating the 'biology know-how' into a 'marketable know-how'.

The CEO knowledge base has two components: the CEO acceptance of the CSO's point of view and the CEO's need to have an expert ('X') available to translate the scientific and technical data into a 'language' that is amenable to decision making. This is illustrated in two statements, one with respect of the CSO and one with respect to 'X':

> *'I couldn't do my job only with the CSO because he could tell me this and I'd have to believe it .... he wouldn't deliberately mislead me, but he wouldn't perhaps have in mind these other considerations that X brings to it... I couldn't do my job without It (referring to X)'*

The interaction with R&D therefore is of particular interest to the CEO. He admits that his interaction with the R&D group is limited but stresses the point that this interaction is important as it is necessary for him to ascertain that the CEO gains their respect and that he is capable of taking them along the growth path of the company. Again, it is argued by the CEO that this interaction cannot possibly be based upon scientific exchanges or intellectual discussions with the scientists but on the premise that he can add value to the business. The CEO does this by allowing them to carry out their research with appropriate financial funding and within certain confines and by making sure that they are protected from the more mundane and perhaps 'less welcome aspects of being part of the company, particularly a public company'. In addition, by looking for the commercial opportunities the CEO is capable of increasing the value of the company and thereby recognizes the work of the R&D function.

The CEO argues that his major concern is the linkage between the science and commercial viability and market opportunities. This linkage between medical need and scientific potential is the major driver for doing research and committing resources to the R&D function. Finally, the CEO argues that there is a danger in being (too) close to the technology and thereby losing oversight and commercial opportunities because 'one has to be able to change track'. The CEO is committed to the R&D function by making available rewards to the R&D function but this is limited to classical approaches used for non-scientific resources (i.e. by using share options and other monetary rewards). There is no mention of adapting a reward system to allow operational freedom, a 'scientist of the year award', or other incentives beyond the monetary approach.

Evaluation of the approach pilot interview CEO2

As a result of the first pilot interview it was decided to engage in an interview approach whereby the open-ended interview technique is replaced by a more focused interview style with more precise questions. It was assumed that by taking this approach there

would be more control on the course of the interview in that it avoids irrelevant and deviating excursions such as the tensions with a specific individual, a historical reflection on the origins and founders of the company, the greatness of the founder etc. The approach that was taken in the second interview proved to be efficient in that it allowed a much more focused and continuous attention-directing approach which did not impact negatively on the interaction with the CEO. During the second interview it was stated by the CEO that the interview was an intellectually interesting exchange of ideas that he was keen to have. Therefore, asking direct and precisely focused questions would not hamper the output of the CEO's points of view and vision on his role in innovation. Also, taking a more structured question-by-question approach allows for a comparative analysis among the interview transcripts.

Conclusion of the pilot interviews of CEO1 and CEO2

Although it is too early in this phase of the research program to compare both CEOs, it may be worthwhile to reflect on similarities and differences between these two top managers. This is presented in the bar chart below. At first glance both CEOs reflect a similar 'role pattern': "CEO attention" (setting direction and giving focus) and CEO commitment (facilitating R&D) are both more pronounced when compared to CEO involvement (actual interactions with R&D). For both CEOs the 'attitude to innovation' is poor, probably because this is considered a fact of life for a CEO in a life science R&D company and therefore both do not consider it necessary to draw attention to it. Involvement is low for both CEOs. For CEO1 (the science-based CEO), involvement in R&D is limited to those aspects of R&D into which he is personally trained or has accumulated experience. For CEO2 (the finance-based CEO), involvement is not relevant as he is not able to contribute in the area of R&D seen his previous expertise and educational background. This is also reflected in the role model that is used by each CEO. CEO2 considers his CEO role model a business-driven CEO (OTH16) while CEO1 considers a knowledge-driven CEO a role model (OTH8).

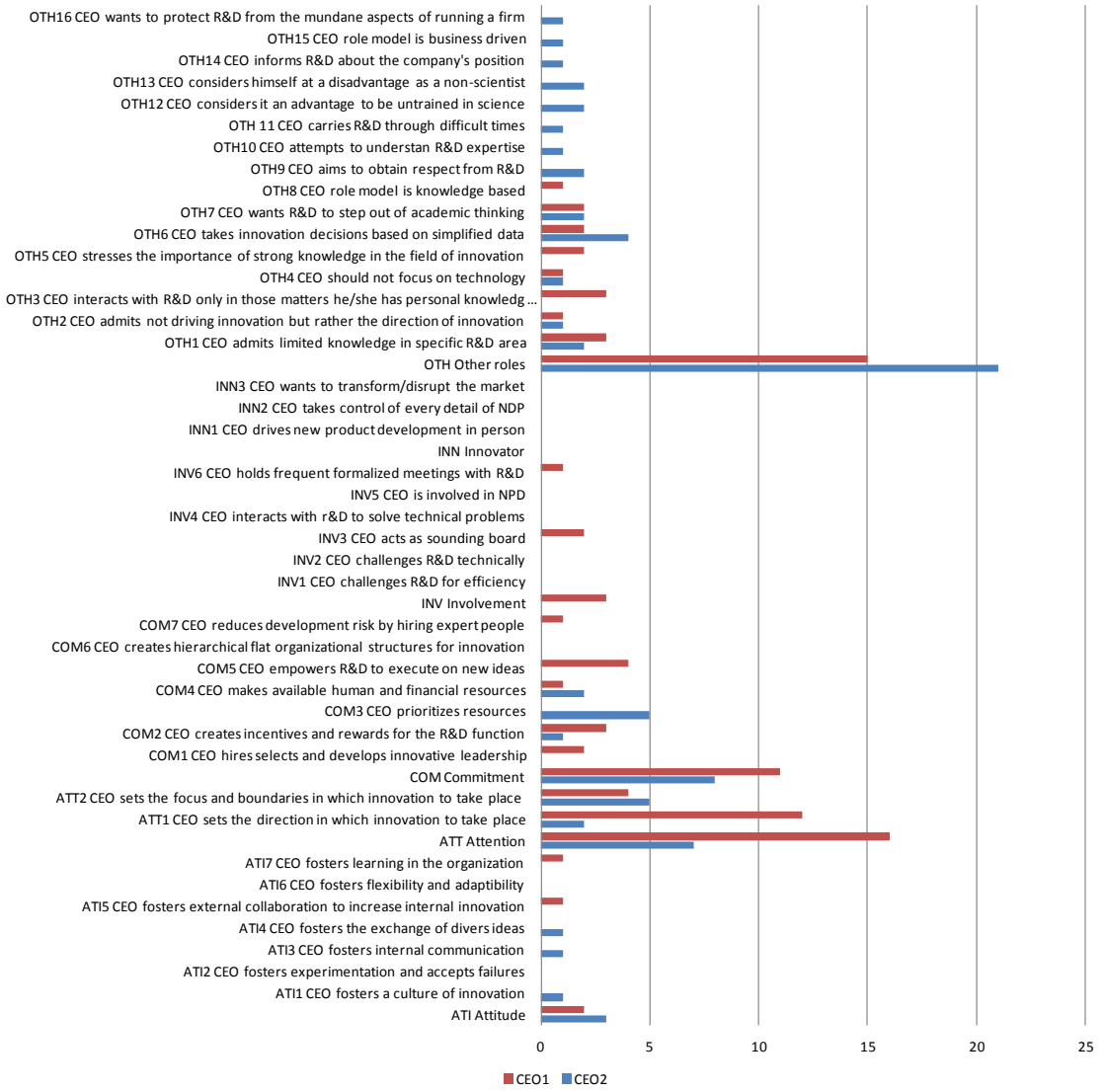
There is a clear difference between the educational and experiential backgrounds of both CEOs, but it is clear that CEO1 only uses the knowledge that he gained either through education or through personal experience, in those areas of R&D that he is acquainted with. Outside the fields of his own personal expertise and experience, the science-based CEO's approach towards R&D does not differ from the approach of CEO2. Both feel that their knowledge into the details of the science is insufficient to drive innovation. CEO1 argues that he does not drive innovation because the core R&D activities are conducted by a specialist R&D function in which he does not have sufficient know-how to play his role and states that 'I do not drive innovation' while CEO2 states: 'I don't direct (R&D)'. Both do so for the same reason: the absence of relevant R&D expertise either in a specific area (CEO1) or in no area (CEO2). Both CEOs have a clear view on the nature of the R&D function in their firms and consider the market-science relationship the driver of R&D. Irrespective of the educational background or experience of the CEO both CEOs found it necessary to translate the complex data in their R&D groups into a more 'manageable' format that allows to make strategic decisions. CEO1 does this by using part of his knowledge, combining this with the output of his R&D

function, linking this with market data and simplifying this so as not to generate 'rocket science'. CEO2 uses a specifically designed individual to translate the CSO's data into a format that allows him to make strategic decisions.

Both CEOs argue that there is a danger in becoming to close with the technology. CEO1 argues that too much focus on the technology may drive a firm into academic research path without generating commercial value, while CEO2 argues that by linking up intensively with a technology the danger exists that the company gets 'stuck' with the technology and cannot move swiftly into another area. There is a difference in the approach used by both CEOs in incentivizing the R&D function. CEO1 not only employs share options as an incentive but also 'empowers' the R&D function and creates operational freedom. CEO2 only uses monetary rewards.

According to Yin, 'interviews will be guided conversations rather than structured queries' and '(the) actual stream of questions in a case study interview is likely to be fluid rather than rigid' (Yin, 2009, p106). Two possible interview techniques are proposed by Yin (Yin, 2009, p107): the *in-depth interview* and the *focused interview*. During in-depth interviews, respondents can be asked about the facts of the matter as well as their opinions about events. The interview may therefore take place over an extended period of time, not just in a single sitting. Focused interviews, on the other hand, constitute a time-limited conversation that is likely to follow a set of questions derived from a study protocol. According to Flick (2004, p204), this type of interview 'unite a high degree of openness and non-directivity with a high level of concreteness and the recording of detailed information; (together with narrative interviews,) it is therefore superior to other interview variants'. Central to the focused interview is the 'focusing on a subject or topic of conversation determined in advance… and the attempt to collect reactions and interpretations in an interview with a relatively open form' (Flick et al., 2004, p205). It is one of the goals of the focused interview to give interviewees 'an opportunity to invoke points of view that had not been anticipated' (Flick et al., 2004, p205). Four criteria for a qualitative focused interview are defined:

- *Scope*: the spectrum of the problems addressed should not be too narrow: this however is a matter of personal interpretation on what 'narrowness' means in view of the proposed interview. In our case, in which CEOs will be asked about their role in innovation, the topic of the interview is sufficiently broad to allow the respondent to allow 'maximal opportunity' to react to the 'stimulus situation'
- *Specificity*: the topics and questions that are posed in the interview should 'be dealt with in a specified way', i.e. the respondent should not generate "general feelings or global assessments" and evaluations, but should generate 'concrete memories that relate to the particular topic'. It is essential in our interviews that the CEOs are not asked for theoretical or global views on their role in innovation, but rather on their actual, concrete real life roles in innovational R&D.



Comparison of the themes emerging from the 2 pilot interviews

- *Depth*: the interview should appropriately address 'the dimension of depth': interviewees should be supported in 'presenting the affective, cognitive and value-related meaning which a particular situations have for them'. It is important in our research to gauge how CEOs feel about their role in innovation: do they consider that role – even if 'played' efficiently – worthwhile, cumbersome, heavy?
- *Personal context*: 'the personal context in which the analyzed meanings and reactions are located must be adequately recorded'. According to Merton et al., 'this is a precondition for the interpretation of any non-anticipated reactions to the communicative contents that formed the basis of the interview'. It is for example necessary to try to understand why, for some CEOs, the responsibility and accountability of their firm's R&D programs may come as a burden. Is it because of their previous experiences, their growth path in their firms?

It was learned from the first pilot study that an open-ended, non-structured interview is a risky interview approach as the CEO offered data which would be difficult to structure against other interview outputs. Also, the open-ended interview approach allowed the CEO to color the conversation with 'war stories'. The second pilot study was more structured and used pre-conceived questions based on the literature concepts and offered an overview of responses that would be easier to contrast with the output of other CEOs. It also allowed to address concepts around the role of the CEO in innovation such as development of innovation culture, role of the CEO, leadership characteristics thereby offering the CEO a structure in which he could put down his/her ideas and opinions. As a conclusion, focused interviews have a number of advantages such as the 'possibility of combining the possibility of a reserved, non-directive management of a conversation with an interest in very specific information and the opportunity for an object-related explanation of meanings' (Flick et al., 2004, p206). It was therefore decided that a more directive and focused approach will be used for the final interviews.

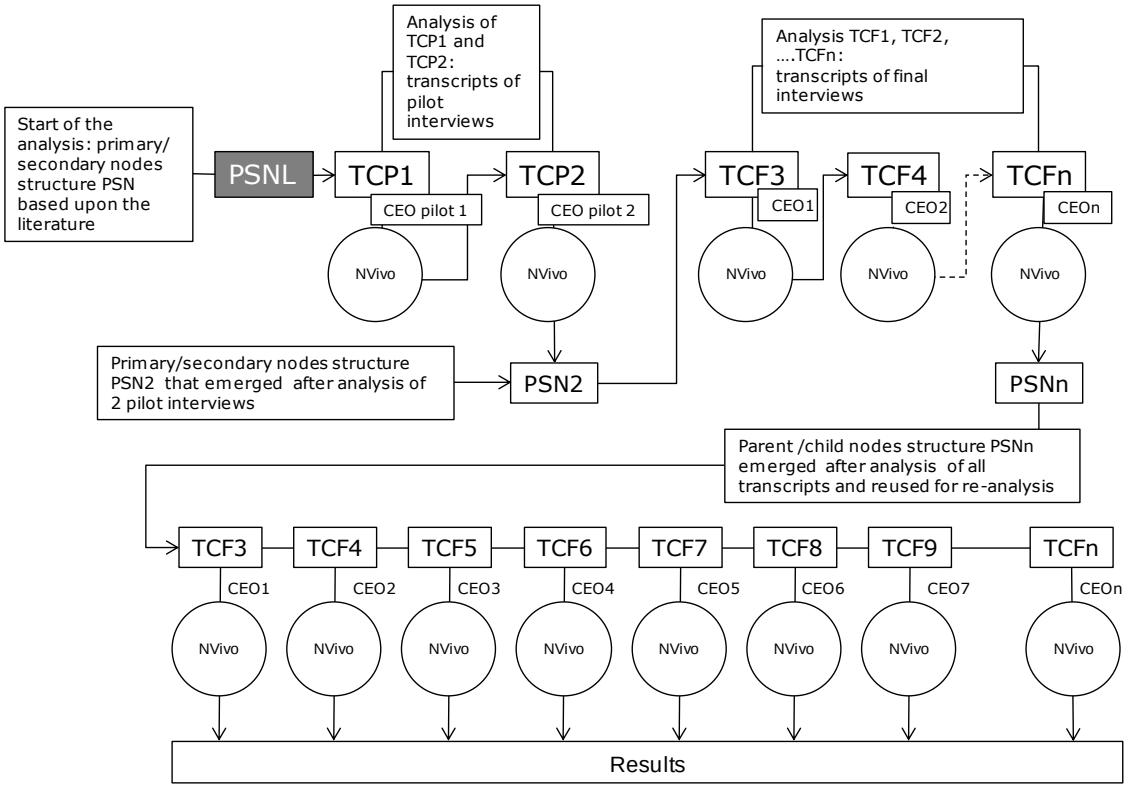
Final CEO interviews

During the pilot research an NVivo primary/secondary node structure was developed that formed the basis for the further analysis of the final interview transcripts. The primary/secondary node structure developed during the two pilot interviews was used as a starting point for the textual analysis for the final CEO interviews is presented below.

ATI Attitude
ATI1 CEO fosters a culture of innovation
ATI2 CEO fosters experimentation and accepts failures
ATI3 CEO fosters internal communication
ATI4 CEO fosters the exchange of diverse ideas
ATI5 CEO fosters external collaboration to increase internal innovation
ATI6 CEO fosters flexibility and adaptibility
ATI7 CEO fosters learning in the organization
ATT Attention
ATT1 CEO sets the direction/goal and vision in which innovation to take place
ATT2 CEO sets the focus and boundaries in which innovation to take place
COM Commitment
COM1 CEO hires selects and develops innovative leadership
COM2 CEO creates incentives and rewards for the R&D function
COM3 CEO prioritizes resources
COM4 CEO makes available human and financial resources
COM5 CEO empowers R&D to execute on new ideas
COM6 CEO creates hierarchical flat organizational structures for innovation
COM7 CEO reduces development risk by hiring expert people and developing options
INV Involvement
INV1 CEO challenges R&D for efficiency
INV2 CEO challenges R&D technically
INV3 CEO acts as sounding board
INV4 CEO interacts with R&D to solve technical problems
INV5 CEO is involved in NPD
INV6 CEO holds frequent formalized meetings with R&D
INN Innovator

INN1 CEO drives new product development in person
INN2 CEO takes control of every detail of NDP
INN3 CEO wants to transform/disrupt the market
OTH Other roles (from the pilot studies)
OTH1 CEO admits limited knowledge in specific R&D area
OTH2 CEO admits not driving innovation but rather the direction of innovation
OTH3 CEO interacts with R&D only in those matters he/she has personal knowledge in
OTH4 CEO should not focus on technology
OTH5 CEO stresses the importance of strong knowledge in the field of innovation
OTH6 CEO requires R&D data to be simplified for strategic decision and communicaton
OTH7 CEO wants R&D to step out of academic thinking
OTH8 CEO role model is knowledge based
OTH9 CEO aims to obtain respect from R&D
OTH10 CEO attempts to understand R&D expertise
OTH 11 CEO carries R&D through difficult times
OTH12 CEO considers it an advantage to be untrained in science
OTH13 CEO considers himself at a disadvantage as a non-scientist
OTH14 CEO informs R&D about the company's position
OTH15 CEO role model is business driven
OTH16 CEO wants to protect R&D from the mundane aspects of running a firm

Data collection: NVivo analysis of the final interviews. The primary/secondary node structure PSN2 developed after the second pilot interview formed the basis for the NVivo analysis of the final interviews. In this study, a total of 15 interview analyses were conducted. Before the interview, the above list of themes was introduced into the node structure of the NVivo software. After each interview the audiofile (*.wav) was transcribed and checked for completeness. At the end of the transcript analyses all transcripts were reanalyzed again using the primary/secondary node structure PSNn, obtained after the last transcript analysis, to ascertain that all themes were retrieved that emerged during the interviews, as presented in the diagram above.


Start of the analysis: primary/ secondary nodes structure PSN based upon the literature
PSNL
TCP1
TCP2
Analysis of TCP1 and TCP2: transcripts of pilot interviews
CEO pilot 1
CEO pilot 2
NVivo
NVivo
Primary/secondary nodes structure PSN2 that emerged after analysis of 2 pilot interviews
PSN2
TCF3
TCF4
TCFn
Analysis TCF1, TCF2, ….TCFn: transcripts of final interviews
CEO1
CEO2
CEOn
NVivo
NVivo
NVivo
PSNn
Parent /child nodes structure PSNn emerged after analysis of all transcripts and reused for re-analysis
TCF3
TCF4
TCF5
TCF6
TCF7
TCF8
TCF9
TCFn
CEO1
CEO2
CEO3
CEO4
CEO5
CEO6
CEO7
CEOn
NVivo
NVivo
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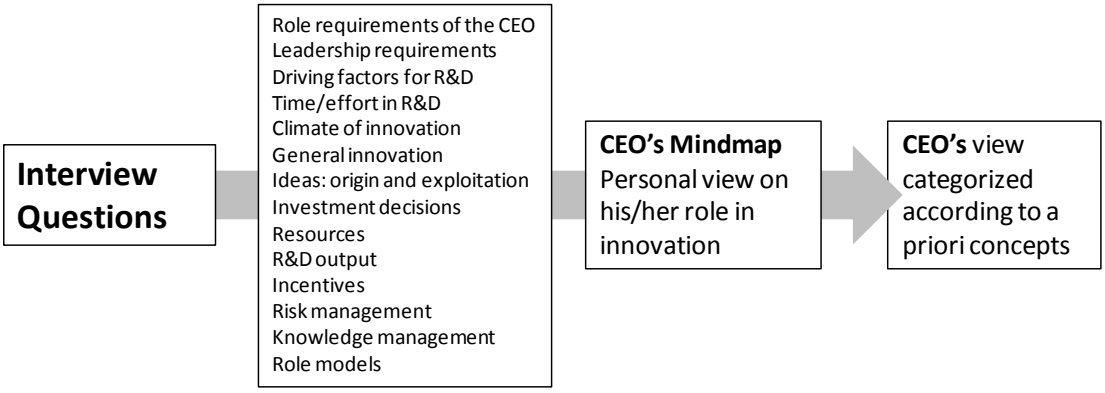
Results

Appendix F. From research questions to interview questions

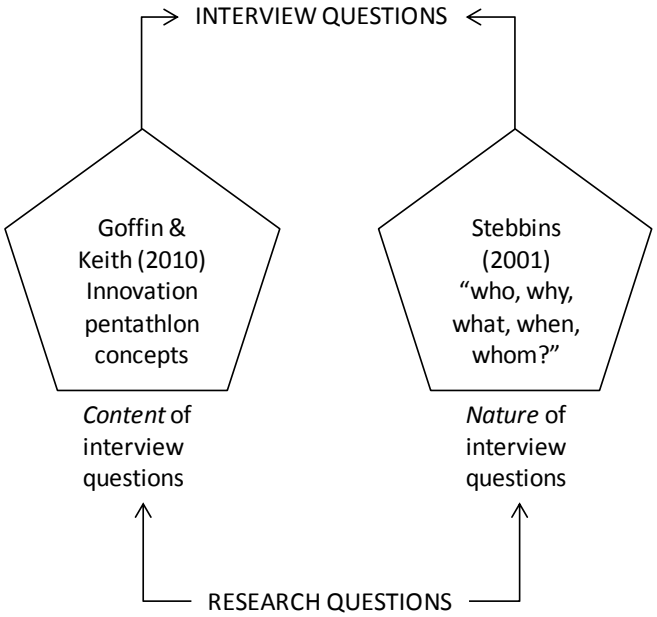
The interview questions were developed from two angles: on the one hand, the pentathlone framework for innovation (Goffin and Mitchell, 2010) was used to develop the *content* of the questions, while the *nature* of questions was driven by Stebbins discussions on questioning in exploratory research mode (Stebbins, 2001, p23). Based upon these two starting points, questions were developed that explored the 'innovational world' in which the CEO discharges his/her role, realizing that the extent of the list of questions should be minimal and taking into account the fact that these individuals only have a limited timeframe available for research interviewing. The approach is presented in below.



The pentathlon of innovation offers a suitable framework to develop interview questions and to explore the world of innovation in which these CEOs operate. These five basic principles are linked to the concepts of ideas, culture, prioritization, strategy and implementation. These innovation themes are introduced into the interview questions. At the same time, Stebbins (2001) argues that 'researchers ... look for the five Ws... (and) ...try to generalize about *who* (is doing (thinking, feeling) *what* to (with, for, about) *whom* and *when* and *where* this action takes place' (italic by Stebbins). The overall approach linking both Goffin and Mitchell's and Stebbin's approach is presented in the figure below.

Development of interview questions. Interview questions were developed that open up the conversation between the interviewer and the interviewee. The interview starts with an 'introductory question' or 'opening question', because they 'may yield spontaneous, rich descriptions where the subjects provide what they have experienced as the main aspects of the phenomena investigated' (Kvale and Brinkmann, 2009). The opening question addresses the role of the CEO in innovation: '*What do you think are the attributes of the role of a CEO in a life science R&D firm?*'. It has two purposes: firstly, it allows the interviewee to spontaneously refer to his/her personal experiences and

secondly allows a friendly atmosphere to be established between interviewer and interviewee. In addition, it does not inquire deeply into the personal experiences from the start. This is followed by a second question that is also of a general nature but looks into the role of the CEO innovation from another angle and inquires about the leadership characteristics of the CEO: '*What are in your opinion the major leadership characteristics of a CEO in a life-science R&D firm?*'



Leading from these two opening questions, the interview protocol passes along a set of questions that focuses on the actual discharge of that role in an R&D environment and how this role could effectively be played. The goal of the interview is to let concepts emerge from the interview. As a result of the answers given to these questions, the interviewer attentively explores the worldview of the CEO by gauging for specific a priori concepts paying attention not to lead questions that may generate a role concept such as CEO commitment, CEO innovativeness etc. Finally, the interview leads to questions whereby it is explored how the CEO-interviewee actually increases the R&D output in your firm, thereby looking for ways in which the interaction with R&D is used as a driver for increased innovation. In preparation of the interview a number of additional questions were developed that explores the interaction with the R&D function in more detail.

One note on leading questions. According to Kvale and Brinkmann (2009), 'in contrast to common opinion, the qualitative research interview is particularly well suited for employing leading questions to repeatedly check the reliability of the interviewees' answers, as well as to verify the interviewers' interpretations'. Because this interview is part of an explorative study, the decisions was taken to confine the interview to the questions listed below but nevertheless to inquire further with non-preconceived questions in order to reach a better understanding of the statements made by the CEOs.

In the following list of exploratory questions, the pentathlone framework concepts of idea generation, prioritization, implementation, strategy and culture have been introduced. Each question is followed by a code that indicates whether the question is of a general nature (G), or addresses a specific pentathlone theme (P). For example, the first two questions of the interview are general and introductory questions and they are therefore followed by the code "G". The third question Q3 addresses the origin of the innovation and therefore is followed by the code "P-idea", the fourth question Q4 addresses the culture of innovation and therefore is followed by the code "P-culture". There are 7 "what"-questions, 11 "how"-questions and 6 "why"-questions which in some cases have been put together in a single question.

The questions are presented below.

Q1. What do you think are the attributes of the role of a CEO in a life science R&D firm? (G)
This is the introductory question which allows to take the discussion further.

Q2. What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm? (G). This question tries to explore the CEO's attitude towards innovation. For example, the CEO response may be that he/she creates a climate open to discussion, ideas etc. Others may argue that is the ability to take risk, to instill trust. Three additional questions follow:

Q3 **What is in your opinion the most important driving force for R&D innovation in the organization and why?** (P-idea)
Q4 **How do you create a climate of innovation and why?** (P-culture)
Q5 **Is an innovational climate important even in R&D firms which should be, by definition, innovative because of the nature of the work?** (P-culture)

Q6 **How much time and effort do you make available to obtain information from your R&D team in percentage?** (G)
This question addresses attention of the CEO to R&D information (internal and external) that he/she can use to develop new ideas for establishing a future for the company. Three additional questions are asked:

Q7 **How are new ideas developed in R&D?** (P-idea)
Q8 **How do you identify new ideas in your firm and exploit those ideas?** (P-idea)
Q9 **Are you actively looking yourself for new ideas in the organization?** (P-idea)

Q10 **What are your driving factors to invest in, make available resources and support R&D?** (P-prioritization). This question tries to gauge the CEO's commitment towards innovation in R&D; several sub-questions can be asked

related to rewards, resources, identification of innovators, incentives to innovation and coping with risk. Three additional questions are asked:

Q11 **How do you as a CEO actually increase the output of R&D?** (P-implementation)
Q12 **What are your incentives to stimulate innovation in R&D?** (P-implementation)
Q13 **How do you live with and manage the risk associated with R&D?** (P-implementation and P-prioritization)

Q14 **How do you bridge the gap between the scientific/ biomedical knowledge in R&D and your (general management's) knowledge?** (G). This question tries to assess the level of CEO knowledge that allows him/her to engage in detailed NPD discussions. Three additional questions are asked:

Q15 **With whom and how frequently (times/w, m, y) do you actually discuss R&D, and why?** (P- implementation and P-prioritization)
Q16 **To what depth are you involved in the NPD discussions and why?** (P-culture and organization)
Q17 **What is your role in advancing new product development?** (P-culture and organization)

Q18 **How do you describe your role as CEO in R&D vs the role of your CSO?** (P strategy). This question tries to explore how the CEO seems him/herself in view of what is to be considered/expected to the major innovator of the firm, i.e. the CSO. Three additional questions are asked:

Q19 **Who takes R&D decisions and why?** (P- strategy)
Q20 **Who decides on the final product design and why?** (P- strategy)
Q21 **Who is the most important driver in new innovations in your firm?** (P-idea, P- strategy)

Q22 **Have you seen CEOs who were particularly effective in driving R&D, and why do you think they are?** (G)

During each visit of the 15 CEOs, the protocol was adhered too as to generate comparable transcripts which were based upon the same set of inquiries. Although our research is not a case study, Yin's argument is valid that 'questions are posed to you, the investigator, not to an interviewee' as 'the protocol questions are your reminders regarding the information that needs to be collected , and why' (Yin, 2009). The main purpose of these questions is to keep the investigator 'on track' as for our data collection to proceed. The interview form is added below.

Cranfield UNIVERSITY
School of Management

Research project The role of the CEO in innovation
Researcher : J. Rosier – Supervisor Prof. K. Goffin

INTERVIEW QUESTIONS TO THE CHIEF EXECUTIVE OFFICER

Place of interview .....
CE: .....
Time start .....
Time stop .....

Q1	What do you think are the attributes of the role of a CEO in a life science R&D firm?
Q2	What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm?
Q3	What is in your opinion the most important driving force for R&D innovation in the organization and why?
Q4	How do you create a climate of innovation and why?
Q5	Is an innovational climate important even in R&D firms which should be, by definition, innovative because of the nature of the work?
Q6	How much time and effort do you make available to obtain information from your R&D team in percentage?
Q7	How are new ideas developed in R&D?
Q8	How do you identify new ideas in your firm and exploit those ideas?
Q9	Are you actively looking yourself for new ideas in the organization?
Q10	What are your driving factors to invest in, make available resources and support R&D?
Q11	How do you as a CEO actually increase the output of R&D?
Q12	What are your incentives to stimulate innovation in R&D?
Q13	How do you live with and manage the risk associated with R&D?
Q14	How do you bridge the gap between the scientific/ biomedical knowledge in R&D and your (general management's) knowledge?
Q15	With whom and how frequently (times/w, m, y) do you actually discuss R&D, and why?
Q16	To what depth are you involved in the NPD discussions and why?
Q17	What is your role in advancing new product development?
Q18	How do you describe your role as CEO in R&D vs the role of your CSO?
Q19	Who takes R&D decisions and why?
Q20	Who decides on the final product design and why?
Q21	Who is the most important driver in new innovations in your firm?
Q22	Have you seen CEOs who were particularly effective in driving R&D, and why do you think they are?

Appendix G. Operational data of the CEO interviews

The table below presents the operational interview data: interviewee code, recording nr, duration of interview, conversation type and transcript length.

Interviewee R&D executive	**Recording Nr.**	**Duration (in min)**	**Conversation**	**Transcript* (nr of pages)**
CEO1P	0060 & 0061	63	face-to-face	32
CEO2P	0062	49	face-to-face	22
CEO1	0063	75	face-to-face	37
CEO2	0064	72	face-to-face	30
CEO3	0065	56	face-to-face	24
CEO4	0062	57	face-to-face	24
CEO5	0068 & 0069 & 0070	71	face-to-face	30
CEO6	0071	55	face-to-face	26
CEO7	0072	52	face-to-face	20
CEO8	0073 & 0074	75	face-to-face	26
CEO9	0075	54	face-to-face	26
CEO10	0067	69	face-to-face	0
CEO11	0120	35	face-to-face	15
CEO12	0113	50	face-to-face	18
CEO13	0147	54	face-to-face	24
CEO14	0141	56	face-to-face	23
CEO15	0135	54	face-to-face	23
		997 min 15.5 hrs		400 pages

*A4, Calibri, 12 font size, 1,5 line space; **: interview not transcribed (CEO mixed French-English speaking).

Appendix H. New subthemes from final CEO interviews

New Subtheme:	Description:	Description as raised by the CEO (examples)
CEO-OTH17	CEO acts as a role model for innovation	"...here you know the leaders of the company are role models for the rest of the company, so how we behave, what we do, our actions speak louder than words, so there I think ... being good citizens and examples of innovation you create then people copy you, they follow you, they do what you do and then it infects the company..." (CEO3)
CEO-OTH18	CEO links R&D to internal and external stakeholders	"... and telling stories to different people to help them understand the other sides of the business, helping the finance people understand what the hell commercial people are doing and in that we're providing a link and a theme for things going forward so obviously the development of that theme and that strategy is a key part of the job but then linking it between the different partners internally and externally and obviously what different people want in terms of the story and how the scientists will think we spend too much time talking about cash and money because most people spend too much time about technical issues you know and its really developing, distilling that story, telling it again and it's really about storytelling, this leadership role is all about..." (CEO2)
CEO-OTH19	CEO reduces risk by fail fast fail cheap	"...I think the only thing you can do is that again you try to put into place the mechanism so that you learn as quickly as possible when you're going to fail, so if you're going to fail, fail quickly" (CEO4)
CEO-OTH20	CEO gets information from all levels of the organization	"...I get it from other levels, I talk to other people as well and they will be in as part of that meeting, so I'll see them all and I'll watch a lot of the interaction, my decisions are based on to some extent what I think of what they're saying to each other, they're having a discussion in front of me and that's very illuminating on a lot of what I see so and I will have spoken to people before we even get into the meeting, there'll be a lot of background information provided before we go into the meeting and when I want to discuss that I'll go and talk to the individual project or scientist..." (CEO2)
CEO-OTH21	CEO role in R&D is not different from CEO role in non-R&D	"I have managed various established businesses, which for me had nothing to do with managing innovation and I've managed an R&D start-up. I think that 90 percent is the same" (CEO4)
CEO-OTH22	CEO looks for the best possible team	"...is to insure that you have the best possible team" (when asked what is important to be a CEO of a life science R&D firm" (CEO4)
CEO-OTH23	CEO requires persistence and resilience in LFSR	"I think there is persistence. People will look for someone who will keep on trying. You know, in this science it's almost impossible to get it right the first time. You're going to hit a lot of bumps on the road and you need someone who can steer the boat around the rocks. That goes back to flexibility, which we mentioned before." (CEO4)
CEO-OTH24	CEO argues that innovation comes from top down and bottom up	"... I think that the driving force is probably a mixture of a bottom-up desire to keep doing things creatively and coming up with new ideas, ... I think that if the atmosphere is right then it happens...keep looking for ways of improving ... On the other hand, there's the relentless need of the company and therefore a top-down approach to being creative, cutting corners, doing more with less, so I think you need that combination. Then you can force innovation" (CEO4)
CEO-OTH25	CEO and CSO are innovative forces together	"... Yes so he/she (CSO) and I play really complimentary roles because lets say (CSO) wants to innovate on the technology, on the base technology ... he wants to push the technology really to the next level, finding ways to make it better,

		cheaper, faster - right - so he is actively searching ... inside and outside the company for the next thing... On my side I want to innovate or go to market strategy so on the commercial side, I'll give you one example we have this beautiful touch screen monitor ... so I said to the team ... look I want to find a way to connect more deeply with our customer..;" (CEO3)
CEO-OTH26	CEO innovates by challenging the organization	"...I think it's a big advantage not being a scientist; I can ask for things that a scientist would not dare to ask for. I think it's a subtle way of creating innovation and I'm not sure even if you were to ask the question people would realise it, but I think there's a lot of push from this inquiring approach that forces people to innovate..." (CEO4)
CEO-OTH27	CEO argues that innovation also occurs outside R&D	"...sure yes absolutely you have people in the IT department who bring in systems and to improve the R&D productivity right so they influence what happens in R&D like for example we have new systems in place for the E-lab notebook and how do you manage data and so that the data integrity is maintained and systems in place so those kind of things were non existent into the old hand written lab note books and we changed all of that into an IT based system where every data that is collected is automatically launched into the E-lab notebook and is stored, archived and so on, so that improves the productivity of the scientists because they don't have to sit and write lab note books and get witness and all that stuff, done automated steps to innovation from the IT side into that" (CEO5)
CEO-OTH28	CEO argues that R&D should always be one step ahead	"...You need to be a step ahead always in innovation and research and the challenge is to get out of the nothing presented here syndrome of people being stuck on certain patterns without being able to look and decide which" (CEO7)
CEO-OTH29	CEO educates the firm's environment	'...it's a huge challenge first of all to get the idea accepted because many people think hey they can't do anything against viruses so it's a young domain physiology in human medicine as well so we have to actually educate people which is nice, we have to educate governments and all kinds of authorities...' (CEO13)
CEO-OTH30	CEO argues that value is as important as market	'...We have a shared ownership, everyone here is proud because we're the only and the first ones and the ones with good technology and good ideas and we are going to make a difference so everyone shares a little bit that feeling so of course in the end our investors want money and of course to survive we need income, there's always some things that I need to perfect but on the other side there's let's say we're not rambles but anyway we're sharing some kind of a common belief that is far more important than the market that we may address at the end' (CEO13)
CEO-OTH31	CEO and R&D should have a relationship of trust and confidence	'... you want to delegate but effective delegate its like trust but verify right so you want to have enough trust in your people and hire the right people to do their respective functions but at the same time have a good way of holding them accountable for the timelines, for deliverables, for the projects...' (CEO5)
CEO-OTH32	CEO should have firm belief in the product	'Like the core rationale why they came to certain conclusion recommendations or decisions, what I want to understand is whether its thought through and that there is a high conviction level of the fact that we're doing the right thing, I want to test this identification, this belief, emotional bond which is often thought through, well thought through' (CEO12)
CEO-OTH33	CEO considers patients as innovation drivers	'...oh the patient is the main innovation driver' (CEO12)
CEO-OTH34	CEO needs to understands process/risks of R&D	'...make sure you're well informed and you're well surrounded and so on top of everything you've mentioned just to make sure that its alright on the record, you also have to understand the correct risk in supply science and when I talk about risk, so ability, high failure rate..' (CEO14)
CEO-OTH35	CEO needs to understand culture of science	'..so you need to understand culture, you don't have to be or to be part of that culture but at least you need to understand they're different cultures so these are people who are sometimes a bit difficult to manage in a team format for

		example, they are individuals and have a pretty strong individual opinion, their opinionated and you have to be able to deal with that CEO14
CEO-OTH36	CEO needs to know how to lead scientists	you have to know how to lead an organization of scientists so in that way you have to understand their typical characteristics and business they're dealing with because they are leading or guiding scientists, its not the same as guiding IT engineers, it's a different breed I think, like its different to lead an organization of …. CEO14
CEO-OTH37	CEO's understanding of scientists is more important than being a scientist	So I think as a CEO in a life science R&D firm you have to understand the life science itself, I'm not saying you have to be a scientist yourself but at least you need to have a thorough understanding of what life science means CEO14
CEO-OTH38	CEO should have some basic understanding of science	'It is important to have some basic understanding of the science that is being conducted..' (CEO10)
CEO-OTH39	CEOs of LFRD firms should not be dominant	I mean in terms of downward management you have to adapt to that, it doesn't work to implement things, you know top down approach in my opinion but that's my personal opinion it just doesn't work with these people, the only way to convince them to do something is to let them understand (CEO14)
CEO-OTH40	CEO needs bottom-up ideas in LFSR firms	Unfortunately its very much top down, the broad things are top down, I basically steer or sell what we focus on and obviously then the bright ideas come from the bottom out of approaches but unfortunately its not very often that it's the other way round, its not that the research and development – and I think we should do this or and all the time that I've been here I think that's happened once or twice (CEO9)
CEO-OTH41	CEO top scientist/top business man/women is ideal	Most important role I think is that you ensure the continuation of the company so in that sense I think important attributes are risk, mitigation, making sure that financials are in order and make sure that you continuously have enough cash available to support your research and development. I think it obviously requires a lot of different skills which you would like to have in one person but specifically in life science that is almost impossible because it requires so many skill sets (CEO9)
CEO-OTH42	CEO argues that simple messages make for flawed decisions	'I do see that and it happening but I find it very, very dangerous with simplification you lose some of the richness and might lead to completely the wrong discussions (CEO8)
CEO-OTH43	CEO – not R&D - should simplify the message	'...its up to the CEO to do the reduction its not up to the scientist'(CEO14)
CEO-OTH44	CEO should make sure scientists can remain scientists (and not become managers)	'... make sure that they become team players and everything but also make sure that they remain scientists and not managers chewing a message that is appropriate to the leader, that's wrong I think...' (CEO14)
CEO-OTH45	CEO should be very flexible	I think first of all you need to be extremely flexible, you need to be able to, I mean your days are always different, certainly if you're CEO of a very small company that means ok you end up doing quite a lot, you end up even making coffee at some point so doing almost everything, you go to finance with the budget, business development, guiding the R&D, you basically are consumed with all these tasks and final decision making as well so I think in that respect I believe you need to be quite open minded and quite flexible as well' (CEO15)
CEO-OTH46	CEOs should be/act transparent	'I realise when I came back to here Belgium that because of their open policy people were committed, they know everything, I don't have to wonder what is the CEO doing, I knew what he was doing because there was very open communication' (CEO15)
CEO-OTH47	CEO can prevent a R&D knowledge gap by growing from within R&D	'...there is no gap because I grew from the science' CEO15
CEO-OTH48	CEO teaches R&D about business	'...what you definitely see as well is that some people pick up extremely fast and these are the scientists with the business mind'(on the question how the firm teaches its scientist about business) (CEO15)

CEO-OTH49	CEO does not need to be a scientist	'...That gap can be bridged but they cannot sit in their ivory tower, if they're too consumed that what they need to do day to day without showing a clear interest or challenge what the team is providing I think you have a problem, I think there needs to be a good interaction but I don't think you need to have a scientific background to lead the company sufficiently' (CEO15)
CEO-OTH50	CEO has no time to talk to the scientists in R&D	'So what I think is important and what I do in practice is different, I think managing and motivating people is very important but I find myself that I have less and less time to do that, managing the company in a practical sense takes more and more time so in daily reality I am much more involved with my industrial partners and management board than I am with the employees of the company' (CEO9)
CEO-OTH51	CEO balances R&D vision with the Board's vision	'… and as a CEO in many of my roles in my career actually I'm also more or less trying to represent, let's say if I'm talking to the investors I'm defending my team so whatever they decide if we go in a certain direction and its mainly driven by what's living here in the scientific team I'll defend that to the investors but on the other side if the investors have a certain request for something like something through their network or they want to see something changed in our company they want more focus, less projects whatever, I'll try to defend the investors versus my people so I'm always moderating … it works nicely' (CEO13)
CEO-OTH52	CEO challenges R&D and is challenged by R&D	'...so its influencing, its managing, its challenging people, challenging the organization but also be challenged and accept the fact that you're going to be challenged because I think its this both way communication that is very important to being successful here' (CEO11)
CEO-OTH53	CEO knows how to challenge R&D because of his experience	'...when I talk to scientists I always tell them up front is look I'm not a scientist, don't ask me questions about how a protocol of a clinical study has to be written but don't try to fool me either because I will figure it out because I've been doing this for such a long time, I know what questions to ask ..' (CEO11)

Appendix I. CEO Interview observations

The positive attitude of **CEO1** towards innovation is reflected in the many references to the creation of an environment that is supportive of innovation. The culture of innovation in the firm of **CEO1** is supported by means of experimentation and failure tolerance (ATI2), an intense internal communication and appropriate organizational structures (ATI3), the exchange of diverse ideas (ATI4), the external collaboration to increase internal innovation (ATI5) and the learning activities that build the innovational culture (ATI7). This positive attitude towards innovation is corroborated by the high number of commitment related statements such as the formal commitment of **CEO1** to drive innovation by hiring selecting and developing innovative workforce (COM1), the creation of incentives and rewards for R&D (COM2), the creation of appropriate organizational structures (COM6) to allow intense communication and exchange of ideas to take place (ATI4). However, these two conceptions of the role of the CEO in innovation (attitude and commitment) do not shape the involvement of the CEO in the actual practice of R&D. The involvement in R&D is low as **CEO1** is not involved in new product development processes which are led by project teams operating in a matrix structure. His involvement in R&D therefore is limited to a sounding board for the scientists (INV3):

> *'that's why I think being the sounding board there and just to say well ...: "by the way have you thought about this? ... or maybe you should talk to this person'*

CEO1 is trained as a scientist but admits that his current knowledge is not sufficient to keep up with the intricacies of modern life science research in order for him to get involved in the every day discussion that take place in the R&D function. To the question to what depth he is involved in the research, he responds:

> '*I am not an expert , you know ... I'm not an expert ... but because I am not an expert, I can bring in this different angle, this different perspective on looking upon things and sometimes try to make suggestions..'*

He considers the absence of detailed knowledge of the content of the R&D not as a disadvantage. The interaction with R&D takes place either during ad hoc meetings or through formalized meetings where decisions are taken a.o. with respect to project prioritization (COM3). The formalized meetings where **CEO1** is involved in discussing the R&D projects are the top management team (TMT) meetings. When R&D projects are put on the agenda of these TMT meetings CEO1 argues that spanning a bridge between the complexities of R&D know how and the general management knowledge residing in the top management team, is difficult. The core of the problem according to CEO1 is that this R&D know-how misses the business proposition that is required by the other members of the TMT in order for them to make sense of the R&D message:

> '*I recognize it's sometimes difficult, it' sometimes very difficult ... also, some colleagues (*referring to R&D*) they ... they love what they are doing , they love the technology, they love the projects but they have no affinity or a limited affinity with what's happening sometimes in the market place'*

CEO1 expects that the R&D representative in the top management team (TMT) shares this concern with the R&D function in order for it to transform their know-how into a message or proposition that "makes sense" at the level of the TMT. This process of "translating" R&D know how into a message that makes sense to non-scientists and can be used in a different environment outside the context of R&D, is a challenge that is shared by other CEOs. **CEO1** does not refer to the concept of "simplification of R&D" as was made by the other CEOs, but the interview made clear that there is a bridge between the knowledge contextualized within the R&D group and that same knowledge in the context of the top management team. During the pilot studies, the CEOs argued that the strategic business decisions need to be based upon information that should not be considered "rocket science" (**Pilot CEO1**) or that an individual may be required to translate the raw R&D data into a practical, business and market oriented propositions (**Pilot CEO2**). These CEOs do not take strategic decisions which are based upon raw data but on a knowledge base that was transformed – either by R&D, by discussions within the TMT or through an individual appointed to perform this task – into a package that is amenable to challenge and decision making. In the case of **CEO1**, he argued that he expects his R&D head to take the "learnings of the TMT with respect to the business proposition" back in the laboratories to make the decision process at the level of the TMT more efficient. This process of transfer of R&D knowledge whereby the data are being transferred from one context to another in order to make it useful for the CEO and the TMT to discuss, challenge and take decisions was a recurring theme in the interviews.

A theme that was also identified during the pilot studies is the argument made by **CEO1** that a too high focus on technology seems to be a risk factor for an innovative life science R&D firm:

> '*I want to avoid that we become too much technology driven .."* and "*I am intrigued by science ... without too much falling in love with the science because that's always the risk*'

This is linked to the CEO's concern that the science conducted in the R&D function may become too much disconnected from market needs. The reason for being "careful" with the technology is **CEO1**'s concern that the R&D function – because it is peopled with highly educated, young and bright individuals - deviates from the firm's main strategy and instead start to focus on the "progress of science". The concept of attention, (giving direction to the company and focusing on specific R&D goals) was not frequently stressed by this CEO. This may be explained by the fact his firm is a subsidiary of a major corporation that puts forward the major objectives in view of direction and focus. As

this is the case, the "remaining" responsibilities of this CEO are to create an environment for innovation to occur, and to be committed to innovation.
In contrast with the other CEOs, **CEO2** makes a sharp distinction between the 'R' and the 'D' in the company. The firm develops novel therapies and a selected group of individuals ("R") experiments with new ideas (which eventually may fail) while the other group ("D") is subject to strict budgetary and timeline control (i.e. the drug development group that is under pressure to reach targets and milestones). The environment that is being proposed as conducive to innovation is one where the real innovators are protected and can experiment with new ideas within specific boundaries and budgetary restrictions. As stated during the previous interview **CEO2** also proposes to keep a "healthy distance" form technology. What is needed in a life science R&D firm is a CEO who

> *'doesn't love the technology too much, who is able to say 'no' as well as 'yes' because ' that is where it goes wrong with people who fall in love with the technology'*

CEO2 finds support for this point of view in the experience he accumulated leading start-up firms where the founder of the company drove the technology. On the question whether the CEO has experienced CEOs who were particularly efficient in driving innovation, this CEO argues that he has not met such CEOs but – on the contrary - has observed CEOs who have not been successful in driving R&D and give the reason why this is the case**:**

> '*...because they've been real scientists themselves and ... what you need to be is someone who doesn't love the technology too much ... I have to be able to say no as well as yes and I think that where I've seen it go wrong is with people who fall in love, its why very often the early stage leaders of companies have to be moved at some point because they've fallen completely in love with their technology and they're no longer objective ... they bring in people like me later on who are hopefully still passionate but one step away ... so I think you see people where they're more dispassionate (and) where they bring fantastic CSO's who do love the technology ... that's fine as long as it's a counter balance which I think the CEO then has to provide where they're prepared to say no it doesn't work, not good enough or there's something better out there and so I think it's getting that juxtaposition of the super CSO and the CEO who brings a little bit more balance, that's his job he has to measure some other thing*'

The separation between the CSO – as the "scientific superstar" – and the CEO as the "direction giver" is raised by many CEOs in this research. It is accompanied by the observation that – because of the complexities of modern life science R&D – the CEOs are not capable anymore to fully grasp the intricacies of the scientific activities conducted in their firms even when they were trained as a scientist. **CEO2** argues that – even with his scientific background (he holds a medical/biological science doctorate) it

is impossible to understand the intricacies and complexities of current R&D. In line with **CEO1**'s observation, **CEO2** requires the R&D teams to re-contextualize their know-how. **CEO2** considers this an important aspect of R&D management and calls the process "complexity reduction". According to **CEO2**, this is required for two reasons: first, it makes the R&D know-how ready to be challenged by the CEO at the same level of challenge as the challenge that is given by the CEO to other company functions (finance, IP). Second, because the simplified data can be used as business proposition to be discussed with the top management team and with outside stakeholders (such as investors). This complexity reduction process is a process whereby R&D know-how is transferred into language that the CEO is able to challenge so that 'I cannot be fooled":

> '*.... yes I'm a PhD in science but I stopped science very soon after I did a PhD so I would never call myself a scientist ... I think one of my most important functions ... is to make sure that the scientists in the company believe I understand what they're doing. One of the things a CEO has to be able to do is that everybody should be very, very afraid of trying to tell him anything that's not true about the science, not that I can compete with these people in the science but I can tell when I'm being told rubbish, I can tell when there isn't support to the idea and I think that allows me to challenge not just the finance guy, not just the commercial guy but also any science that is presented to me, or all clinical data that's presented to me, ... most importantly I think the ability to be confident to say I don't understand what you just told me, tell me again until I do and we're not leaving the room until you do...I take three times to understand it but if I don't get it by the third time it's their fault, there's something wrong about their logic. I think that what all those need is to be sure that the leader in the organization can challenge them equally effectively, if I couldn't do it with the science it's a bit like me saying well I don't understand finance*'

According to **CEO2** the process of reducing complexity is a bimodal concept because it is not only important to allow appropriate challenging and to make strategic decisions but also to serve the whole company, its shareholders and its internal / external stakeholders. The simplified R&D know-how "should not only make sense" to the CEO and the TMT but should also be the basis for "story telling":

> '*I think the other key thing is to be able to reduce this complexity to simple ideas, one of my current themes in the organization is that the technical people will come and present me with a new idea and it will be 35 power point slides set and by number 3 I'm already twitching .... the idea that you can't reduce half a pager to one or two slides, an important idea or concept .... I think the ability to help people package these things for whatever audience it may be and distil out the important, the core, when you've got so much heavy technical stuff and potentially heavy commercial stuff and clinical stuff all floating in there: what's the thing at the heart of that? what's the business proposition? what's the thing you take to an investor?*

what's the thing you say to a new employee as you're trying to track him into the company? what's the distillation of all this complexity because we could take a year to tell you what we do or we could take five minutes to tell you what we do? ... and I think it's my job to be able to do the five minute elevator pitch so I think that communicator as a leadership thing is very important. So I do a lot of the internal communication as well as external and talking to people like the scientists, help them understand that side of the world to explain why it is that happens and what it is that we have to do in order to get support from the rest of our stakeholders so it's really making sense of the world and telling stories to different people to help them understand the other sides of the business, helping the finance people understand what the hell commercial people are doing and in that we're providing a link and a theme for things going forward. So obviously the development of that theme and that strategy is a key part of the job but then linking it between the different partners internally and externally and what different people want in terms of the story and how the scientists will think we spend too much time talking about cash and money because most people spend too much time about technical issues you know and its really developing, distilling that story, telling it again and it's really about storytelling, this leadership role is all about, again people define that story'

It means that the "complexity reduction process" serves the "story telling" activity about the firm and its scientific assets. According to CEO2, the story telling and the associated internal and external communication is one of the key points of his role in a life science R&D firm. This priority for communication is clear from the number of times the CEO reflects on internal communication (ATI3). These factors are linked to the need for implementing appropriate structures to communicate effectively (COM6).
The third interview took place with a CEO who leads a firm that is developing advanced screening systems for the early detection of disease states. **CEO3**'s view on innovation in the firm is that top management needs to act as a role model in innovation in that "the leaders are role models for the rest of the company, so that our actions speak louder than our words..." Innovation comes first top down and then "infects" the company, whereby the selection and recruitment of innovative individuals is a requirement for innovation to percolate through the organization. When asked about the knowledge distance between the R&D team and himself, he argues that this is a problem:

'....there is a communication gap right and so the language that you use to explain something is different between the science with the vocabulary gap in particular...'

The vocabulary gap between R&D and the CEO can however be bridged. The CEO argues that the scientists in R&D should make an effort to translate the essentials of their work into a message that can be communicated to top management:

'... the essence of what it is that you're discussing is simple, even if it's a technical issue and if you can't translate a technical issue to a common sense business language discussion and really have a discussion on the principles, on the core of what is really happening there then either – you know - there's a communication gap or you don't fully understand really what's behind it and so I find it maybe puts a little bit of a challenge on the scientists, it requires them to spend a little bit more time communicating, they can't quickly just – here is a report right.... they need to take that one extra step of translating a technical conversation to a common sense conversation but I think in going through that effort you end up having a much deeper discussion, you don't have a superficial buzz word, technical driven discussion, you really get to the heart of the issue, the root cause, the root challenges and so I think you have a much more robust discussion if you're able to translate the scientific point to a common sense point, so I think in the end result its actually very powerfully helpful for the teams ... it just requires a little bit more energy for them...'

This approach is similar to the approach which was used by the previous CEOs who argued that if the scientist cannot convince them about the value of the project, he (**CEO2**) will "quit after three attempts" because then "there is something illogic in the message that is being brought". CEO3 argues that the context of the R&D message is an important part of the efficiency of the communication:

'*.... let me take the extreme example, assume somebody is trying to fool you on an issue ... and they come with a scientific explanation, right, which you're missing as a context in which that exist... so if somebody wants to then explain me to go (*into the direction of*) X and you miss the overall context where X is one of 100 different things ... so why X versus Y? ... if you don't know that 99 other scientific approaches are available, then you're missing that context, so you rely on the individual to explain ... that context to you, you don't have that base context'*

The concept of context seems to be an important parameter for **CEO3** to appreciate the message received from R&D. The context under which the R&D data have been collected is different than the context under which they will be used and will show its value. During this transfer process of R&D data is "reconfigured" into a context where it's usefulness and potential value is shown to the CEO. **CEO3** agrees that this is not an easy job, realizing his non-scientific background (he was an investment banker prior to his job as CEO), however, he/she considers this also to be an advantage for him/her as he/she can get right to the core of the problem:

'...and so that's the one disadvantage you have as a CEO with a non scientific background: when a scientist is trying to explain something to you, they've a greater ability of narrowing the discussion to a topic that they want to discuss and not really providing the full picture on the table

> *... and here you know I need ... the right people in the company: ... individuals that are really not trying to get their point approved but really are trying to think from the company perspective so people who are leaders who know that you need to bring this broad context or having the discussion in a good way... so it's really you rely more heavily on your scientists so there the talent search that you talked about is even more important and secondly I use ... scientific advisors, if it's really an important question, I bring other people to look at it, ask their advice so you bring scientists in to help you, so I think there you have to be a little bit careful on that one weakness that you have as a non scientist, there are huge advantages but there's disadvantages as well'*

The fourth interview (**CEO4**) was conducted with a CEO who has a very specific view on leading a life science R&D firm in that he considers the leadership of such a firm not different from any other firm. When asked whether he could easily switch from this type of company to another company outside of life science R&D, his answer is positive because the "fundamentals" would still apply: choosing the right strategy, insuring that you have the best possible team, having a mixture of flexibility and discipline and finally, in case of a small biotech company, ensuring careful cash flow management:

> '*I have managed various established ... businesses, which for me had nothing to do with managing innovation and I've also managed an R&D start-up. I think that 90 percent is the same... You need to take the time to learn at least the music that is going on. You need to ensure that you have the right team below you, especially in the area in which you feel you're less competent ... the 10 percent is about the adjustment you have to make. ... You need to take the time to learn at least the music that is going on...'*

Innovation can "be forced upon" an organization by means of two approaches: by continuously challenging the status quo of R&D and of the organization and by hiring the scientists to people the R&D function in order to come up with the most innovative scientific approach. Innovation can be initiated by both the CEO and the CSO: each of them have the task to innovate from a business perspective and through the scientific objectives (OTH26), respectively . In addition, in order for innovation to occur, communication should be fostered through all layers of the organization (ATI3). When **CEO3** is asked about his relationship with the R&D function, he uses the metaphor of the "lyrics" and the "music":

> '*I do not understand the science so I cannot go into the details of the science but I know what the key projects are and I try to understand what is going on. I always say that I want at least to understand the music. I don't understand the lyrics but I need to understand the music and I need to be able to challenge and then I will challenge (*R&D*) people. That is the approach'*

CEO4 admits that he is not capable of understanding the "lyrics" of R&D (he holds an MBA and has no scientific background), but is capable of appreciating the "music". The "music-lyrics" metaphor is explained as follows. The "lyrics" that **CEO4** is referring to, is the "hard R&D data" consisting of biotechnological vocabulary that is only open for assessment, evaluation and discussion by experienced R&D researchers. These scientific "lyrics" are incomprehensible for **CEO4** and in order for him to make sense of the data, he requires them to be communicated, not through the "score or the text of the piece of music" but through its essence: the music itself. This "music" can be appreciated or criticized by anyone, even by those who do not understand the lyrics or the score. Reducing the score and the lyrics of a piece of music to the actual music (what is heard) is – fundamentally - a process of complexity reduction. During his interactions with R&D, **CEO4** wants to understand the basics of the science that takes place in the firm, as to make up his mind whether or not this "makes sense":

> '*The idea is to go down the organization and to have meetings with the actual teams, who will explain what they are doing, .. one is for me to understand the music a little bit better. I will not follow the (R&D) leaders, that I know, but at least I will know a little bit better*'"

The message conveyed by **CEO4** illustrates his/her need to have data extracted from R&D that is of such a nature hat it can be challenged appropriately. **CEO4**'s involvement in R&D is limited to the challenging of the R&D function for "efficiency", not for technicalities or scientific opportunities, i.e. by a search for alternative approaches that may cut time and spend less financial and human resources. **CEO4**'s technical involvement in R&D is not possible because of lack of technical know how. Even for **CEO2,** who was capable to differentiate "rubbish from science" because of his scientific background, the intricacies of the R&D know how are so complex that a simplification step was required, in other words: even for CEO2, the "lyrics" needed to be reduced to the "music". This limited involvement in the actual R&D practice, i.e. in the details of the R&D, is applicable to all CEOs interviewed as they are not involved in the day-to-day activities of the R&D function. For example, **CEO1** stated that this is left to the team ("I am not involved") while **CEO2** is only introduced at the start of the project after which it is delegated to the R&D team and who is "generally only involved when things go wrong".

CEO5 manages a pharmaceutical company that develops new therapies based upon a novel molecular biology technique and holds a Ph.D. in molecular biology. When asked how he manages the information flow from R&D, he states that one should:

> '..*break it down to the most simple common denominator, simplest form of the issue, so yes you can get bogged down into this miniature but I always try to keep it in a very simple form, simple is better for me right always and so I tend to probe in a very simplistic way and try to get to the most simple*

explanation, essentials, one of the things that we're trying to accomplish, you know what is the end goal of whatever you're trying to accomplish and what are the hurdles along the way that you are encountering and how can we overcome all these hurdles and what can I do to help overcome that, maybe we don't have the right expertise in house, you go out and get KOL's, key opening leaders or consultants or people who have done this before, encountered something similar and can encourage them to think'
'*I spend a lot of time with my business development people, communication person and so on in trying to synthesize all of that body of information into a very simple form for the investors to understand, if we start talking to investors about ... they just get lost so we can simplify it, dumb it down to a point where its very simple concepts to simplify, that's my job and that's the job of our communications people and the business development people*'

CEO5 expects the R&D function to modify their know-how in such a way that it is reduced to its most simple form in order for him to make the strategic decision process easier:

'*... I try to say: if you were talking to your 10 year old son how would you explain what you're doing, what you're trying to do...*" .... "*you know if you're going to a warm buffet and meet someone who doesn't understand anything about science, how would you get that person to invest in your company by simplifying what you're trying to do?*'

CEO6 uses similar arguments when asked how he transfers knowledge from the lab into the management team meeting. The only approach that allows him to take strategic decision is to reduce the science into a less complex dataset that allows the TMT to take decisions. **CEO6** argues that he wants his R&D team to prepare for this simplification step:

'The key is to the leadership team can simplify the case ... it's easy to get lost in complexity … And raw data, I think what we're quite good at it but it only develops by practicing is that we're able to simplify the problem or the story to the essence so that we can look at it from a business point of view so that we can look at the business case and yes this role is extremely complex but if you ask the right questions I think you can simplify it to a certain level that you can make your decisions and you can also communicate to even less sophisticated people also the board about your complexity, your decisions'

and to change the R&D function's behavior in that regard:

'...so one of the things I learned is don't try to download your complexity on your boards because then they go bananas but we're also training the

scientists to not download all their complexity on the leadership team so they know which questions we will ask, so they're forced to crystallize the research reality along answers to simple questions, they're always the same questions, they know that, they know them by heart'

CEO6's need for technology simplification is linked with his concern for the marketability of the technology developed in his biotech firm and again – as observed above with other CEOs, his/her concern that the technology will "take over" :

'Now biotech .... is a typical technology push, what I mean by that is you have the creativity, you have the ideas, you don't need to stimulate them, they are already there and the big question is finding out as soon as possible whether that innovative idea is relevant for the markets ... so if you talk about the role of the CEO as of day 1, one of the things I have been doing in (name of company) is I have been testing the market as soon as possible on the relevance of the idea which we had internally because a big pitfall of a technology push company is that the scientists are then offered the technology of the products, you work two, three, four years, you come out to discover there's nobody waiting for that product and I think that's a typical problem for biotech companies, they wait too long with a confrontation with the market, so when I talk about creating the vision of the company one of the things I have been doing as of day 1, even before we had a business plan is going out to talk to customers or potential customers and understand if I would deliver this, is it of interest to you or what do you expect me to do in order to make it of interest to you and feeding back that feedback to the lab, to the R&D organization, focusing them on delivering something which is relevant..'

The 7th CEO's main objective is to set the direction and focus of the innovation to take place (ATT1, ATT2) and therefore considers himself to be the main driving force for innovation in the firm. Innovation in R&D is a matter of setting ambitious goals to the R&D function and to develop appropriate organizational structures to allow internal communication to take place. **CEO7** argues - as was the case with the previous CEOs - that the R&D function should be "pulled out" of their academic thinking and look to the market needs and to interconnect among each other and with the outside R&D community. The latter approach is required seen the academic pool from which the R&D scientists are recruited and it allows them to act in line with their expertise and experience. **CEO7** states that he is capable to increase the output of R&D when the teams are challenged from a managerial point of view and not necessarily from a technical point of view. There are no specific incentivizing approaches for the R&D function besides the use of spot-bonuses for exceptional efforts. With respect to final decision making, **CEO7** argues that even if the process is more or less "democratic", the ultimate and final decision is taken by the CEO and therefore it is he who takes the ultimate and final decision. The fact that a decisions is taken by input from all members of the TMT, it does not mean that the final decision is a decision made by the TMT: it is

a decision made by the CEO. The CEO gets the information and input on his decision from all levels in the organization: from the VP R&D, from the R&D managers and from individual scientists.

CEO7 realizes that even with his/her medicines/biology background there is a difficulty of technical challenge of the R&D function seen the fast developments in the area of R&D. **CEO7** states that the need for transferring knowledge from the R&D group to him and from him to the board requires a stepwise simplification approach that will increase and become more important as the company will grow. This simplification process goes hand in hand with a "synthesizing" approach whereby the data are structured and presented in a format that allows appropriate communication either within the company or to outside share/stakeholders. This process of R&D knowledge transfer currently takes place from the chief scientist to the CEO and to the board. It will probably – according to **CEO7** - develop into a process whereby the chief scientist will transfer simplified data from the R&D function to the CEO:

> 'at one time in the future, the chief scientist will know much more than I do and it is he who will then need to simplify the data, the same way as I am currently transferring simplified data to the board'

CEO8 is an atypical CEO in that he has received a business education (MBA), has extensive experience with an international reputed business consulting firm, has no prior biology/medical professional or educational background but nevertheless runs a company that develop drugs for the treatment of a number of diseases. In addition, he does not (want to) use the title of Chief Executive Officer but rather that of "Managing Director" as that is what he is actually doing: giving direction to the firm and manage the strategy towards the goals he has put forward (the vision). His position with respect to the need for a culture of innovation is not different from the arguments used by the other CEOs. However, his approach in dealing with the R&D function and the data that they deliver is essentially different from the other CEOs. When asked how he bridges the knowledge gap between the knowledge available in R&D and his general management knowledge, he argues that such a bridge does not exist. While some CEOs refer to the scientific data and their complexity in terms of a metaphor of "music and lyrics", or require the data to be "simplified" i.e. that it be submitted to a process of complexity reduction, this CEO assures that he is fully capable of understanding the science that is taking place in his firm and is also fully capable of transmitting the original, non-simplified message, because

> *'...our chairman knows more about the science than I do, there is no need to simplify the data or reduce the complexity of the science I am putting on the table at the board'*

The danger of simplification, he argues, is that it may potentially lead to a flawed decision making process because it removes the richness of the data and may lead to the wrong conclusion. If a board has to make decisions based upon R&D data, it will first need to be elevated – educated - to a level of scientific knowledge such that the raw data can be communicated in its 'original' format. **CEO8** argues that the process of

accepting, evaluating and transmitting R&D data is - at most - a process of synthesis backed up with the raw data but not a process of simplification. When asked about the difference between a CEO and a CSO in this firm, the CEO '*holds and knows all the scientific details and data'*, and argues that the CSO is capable of handling and discussing everyday lab-practices and the scientific details and concepts but is not assessing, screening market environments. In this firm, therefore, there seems to be a "R&D continuum" from the R&D laboratories over the leadership team into the board. **CEO8** accepts that the situation may change when the company will grow and that this transfer process may have to change. This was also raised by **CEO7.** Although the findings in this interview may not corroborate the observations made on the concept of transfer of R&D knowledge in the other firms, it points to the impact of the context under which this transfer takes place. In some firms, this knowledge bridge may be large and a complexity reduction process is required, while in other firms, this knowledge bridge is minimal and the knowledge transfer is – at most – an exercise in a "synthesis of R&D data".

CEO9 is the young CEO of a life science diagnostics company and has received a top science education (biomedicine and medicine). Nevertheless he/she argues that since the time that stopped doing research and became involved in the company, he/she has never been able to keep track of new scientific developments and to keep pace with the work of the scientists in the lab. Since he/she became CEO of the firm, it has become virtually impossible to understand the knowledge generated in the lab, even with his/her remarkable background:

> *'...a specific disease and specific genes ... that's where I have my knowledge and can place them into a context and see if it's logical or if it works ... so if they come up and say: ... based on our analysis of 50,000 process on a 1,000 patients we use these kinds of analysis... I don't even know what it is, I don't know how to spell what they're doing but at the end... that's where I tap in, its logical what's happening here and so it doesn't really matter that I have that specific knowledge, …'*
> *'I'm involved with people that are doing bioinformatics, who have to simplify what they are discovering to me... but they have to make clear to me what they have found and how they came to that process in very general terms that I understand so ... I always want to understand it.'*

He/she argues that there is a specific skill set associated with the capability of a scientist to be able to explain complex things:

> *'... what has always intrigued me is the following : ... if you go to a lecture of a PhD student that has started two years ago, it is impossible to understand what he's saying, it's impossible and nobody really understands ... the head of department tries to understand what he's saying ... if you would go to another floor and meet a Noble Prize winner who is giving an overview over the work he has been doing in*

the last few years - although its far more complex what he has seen and what he has done - almost everybody can understand it..'

It is therefore important to:

*'... bring it (*the R&D knowledge*) into convincing digestible pieces of knowledge...'*

CEO10 is the founder CEO of a R&D company who has left the world of science already 10 years ago and has since then been involved in strategic matters and giving the direction and focus to the company. He/she has recently hired a chief scientific officer who is looking for alternative ways for identifying promising new therapeutic molecular leads. Using the same arguments as CEO9, he/she requires the data of his scientific teams to be heavily reduced in complexity for him/her to make sense in order to discover the underlying strategic information that allows him to proceed with the firm into a certain direction.

CEO11 and **CEO12** are both CEOs of a major pharmaceutical firm. They were introduced into this research to compare their roles in innovation versus the roles in the CEOs. **CEO11** has a legal background but was a business development manager since the beginning of his career. When he/she was appointed CEO of the firm, he/she argued in a local newspaper, when confronted with the question whether he/she will be able to interact with the R&D team:

'*... they will not fool me*..'

thereby repeating the argument of **CEO2** who argued that '*I cannot compete with these people in the science but I can tell when I'm being told rubbish, I can tell when there isn't support to the idea...'.* These CEOs seem to be capable to extract from a set of complex pieces of knowledge that specific information that is important for them to make strategic decisions on the conditions that the knowledge from R&D undergoes a transformation to allow the CEOs to value the knowledge. According to **CEO11**:

'... I don't have a scientific background. First of all I think what you have to do is to recognise for yourself what it is you know and what it is you don't know and especially from a scientific point of view, surrounding yourself with good people who complement the knowledge you are lacking, people who have strong scientific training, who have insights, ... and who can help you to understand what it is from a pure scientific point of view what's going on and then asking questions towards your scientists ... when I talk to scientists I always tell them up front: look I'm not a scientist, don't ask me questions about how a protocol of a clinical study has to be written but don't try to fool me either because I will figure it out because I've been doing this for such a long time, I know what questions to ask and sometimes I ask questions because

based on ignorance by which they are taken by surprise because its not a question that they will expect from a scientist …'

CEO11 uses his/her experience as a basis for his/her capability to evaluate R&D knowledge. The prior knowledge that resides in the CEO is not science or scientific management but experience in how the science can be used for economic objectives. These remarks are comparable to those of CEO4 who argued along the same lines that it is an advantage not to be a scientist as it allows the CEO to ask the 'right' questions, i.e. those that R&D does not expect. As was argued by previous CEOs, CEO11 requires R&D scientist to be able to decomplexify their knowledge:

'Look ... you probably need both kinds of people, very strong in the science but maybe not that good in communicating on what they are doing and trying to translate that into what I would call normal language that is: such that the marketing guy will understand, the CFO can understand and other people can understand what this really means...'

For the CEO to be able to grasp the knowledge that is generated in the R&D department, this knowledge needs to be calibrated to the level of the CEO. What seems to take place is a titration whereby the knowledge levels of both parties, the CEO and R&D find a common ground that, on the one hand, retains the core of the message that R&D wants to see conveyed and, on the other hand, allows the CEO to use his prior knowledge and experience in order for him/her to challenge it. It seems that the prior knowledge of the CEO (either obtained through education or through experience) drives the calibration of the message from R&D such that the CEO can challenge and evaluate it. Even CEOs with a strong educational science background require a decomplexification step seen the pace by which science evolves and the speed by which a CEO's knowledge is out-dated if the CEO is not actively involved in the science.

Another CEO of a large pharmaceutical corporation that was included in the interviews was **CEO12**. In contrast with **CEO11**, **CEO12** is an academically trained chemist with a pharmaceutical marketing background. The fact that he/she has a scientific background creates self-confidence when interacting with the RD team:

'... well I'm a chemist by training so they cannot really catch me totally off guard, so ask silly questions, make them explain and ask, ask, ask, if you come to the fifth why usually you get an answer that even you understand, that even I understand.. what I want to understand is whether it's thought through and that there is a high conviction level of the fact that we're doing the right thing, I want to test this identification, this belief, emotional bond which is often thought through, well thought through...'

The CEOs of the large pharmaceutical firms seem to use the same approach used by CEOs of SMEs. It seems that CEO background and not firm size seem to be an important role in trying to assess the value of the R&D knowledge.

CEO13 is the CEO of a small highly R&D intensive company with a strong scientific background in organic chemistry although he/she currently runs a small R&D company involved in developing antiviral compounds. He/she argues:

> *'..I'm not going into depth into the science, I'm just trying to understand enough so I can sell the idea' and 'I'm trying to understand as much as possible that I feel that is necessary for my investors to be comfortable with it or to invest in it or – so its kind of a translation'*

CEO13 considers this simplification step required for him/her to communicate the knowledge to the board because

> *'...a lot of them are actually totally unaware of what happens in biology or virology'*

CEO14 is a bio-medically and medically trained CEO of a small R&D firm that develops new drugs in a specific therapeutic area. He/she beliefs that a CEO of small life science R&D firms should – first of all – know *how* to lead scientists because scientists are 'very different from other people'. When a CEO fully understands the implications of leading scientists, there is no need for a CEO to be a scientist:

> *'... you have to know how to lead an organization of scientists so in that way you have to understand their typical characteristics, it's not the same as guiding IT engineers, it's a different breed I think, like its different to lead an organization of sales folks, so you need to understand culture, you don't have to be or to be part of that culture but at least you need to understand they're different cultures so these are people who are sometimes difficult to manage in a team format. For example, they have a pretty strong individual opinion, their opinionated and you have to be able to deal with that, it doesn't mean you have to accept that but at least you have to be able to realise that and then maybe bring them into some kind of framework that is optimal for the company and may not correspond entirely with what a scientist would like but at least you have to be able to communicate...'*
> *'...a scientist is not a team player, by definition is not a team player, a true scientist is not a team player at all, you don't find new things playing in a team...'*

However, in contrast with other CEOs who argue that R&D knowledge needs to be simplified when it reaches the top of the organization and in contrast with CEO8 who argues that such simplification is not necessary, **CEO14** offers a third angle to this

concept of complexity reduction in that it does not need to be conducted by the scientists but on the contrary by the CEO him/herself. According to **CEO14** this approach will avoid the CEO to make the wrong decisions, which was one of the arguments of **CEO8** why such simplification step is quite risky. **CEO14** argues:

> *'by simplifying things you induce another variable (in the decision making process), the more variables you have to deal with the more difficult the decision will be and so the outcome becomes unpredictable. Simplification does not remove the variables ... they don't disappear by this simplification'*

According to **CEO14** this complexity reduction step is to be conducted by the CEO him/herself rather then by R&D. CEOS should not be afraid to 'dive into' the complexity:

> *'... I think its up to the CEO to do the reduction... it's not up to the scientist, it's up to you as CEO whether you can live with that or whether you go back to the scientists and say what the hell is going on, that's up to you but the fear of hearing a message you can't deal with..., it's so easy to decide on a single message versus multiple messages, versus complexity...'*
>
> *'There is a certain machismo in this business ... as a CEO you have to understand everything and then you decide right away....:, if that's your behavior, complexity doesn't fit into that kind of behavior unless you are extremely smart and willing to take risks, ... but I'm willing to take the risks, yes I will take decisions if they ask them, yes I will deal with complexity...'*
>
> *'The point is if the scientist will reduce complexity before they discuss it with you because they think that you won't like it, ... it's your fault because it's their perception that you want to have it like this, that means that you have told me things in the past that are not right,(I have to make sure as a CEO) that ...they remain scientists and not managers chewing a message that is appropriate to the leader, that's wrong I think'*

According to **CEO8** and **CEO14** the complexity reduction of R&D know how should not proceed for two reasons: first, there is the risk of taking the wrong decision because the simplification has removed some key variables which were required to make the right decisions, and secondly, if a complexity reduction has to take place it is not the scientist but the CEO who should do the complexity reduction.

CEO15 is an atypical CEO as he/she grew from within the R&D function into the CEO position, and therefore there is no knowledge gap observed at all at all between the R&D function and his/her knowledge base.

> *'...that's basically because I grew out of that environment and I think that it's an advantage as a CEO ... you understand it really well*

> *because I've also noticed that if you're too close to what you're doing you sometimes don't see the bigger picture'*

CEO15 however argues:

> *'I think I would say from my end, there is no gap because I grew from the science, what I have to be very careful with is (and what) I want to avoid, (is that) there is a gap from the other side so I know what they're doing really well but I want them to be involved as much as they can to also see the business side of things so that they can help things think through ...'*

In other words, the knowledge gap that – until now – was identified as a gap in scientific knowledge between CEO and R&D, is also a gap in 'business and market' knowledge that may help to arm the scientists with the necessary knowledge to steer and make sense of their R&D activities. In other words, the knowledge gap is bifocal, either it is science - based from the perspective of the CEO or its business - based from the perspective of R&D.

Appendix J. Procedure for the focus group research

All 15 CEOs were invited to attend the focus research group, realizing that it is 'important to recruit to cover for no-shows' (Morgan, 1997). The CEOs were invited using a letter of invitation in which the objective of the meeting was explained. Of the 15 CEOs who were invited 5 agreed to join the focus group. On the day of the focus group meeting, one CEO informed that he/she was not able to make it. This led to a final research focus group of 4 CEOs. Other CEOs were also interested to attend the focus group but were not available at the specified date and time. An attempt was made to create a second focus group but the availability of the CEOs proved to be a difficult problem: only 2 CEOs could make themselves available for the secondly proposed date. Because this number is considered to be too small for a focus group, the second focus group meeting was cancelled. All 4 CEOs were part of the first group of CEOs and also agreed to have their senior scientists interviewed. The table below lists the 4 CEOs who joined the focus group. CEO1 changed company since the first interview and – at the time of the focus group research - acted as the CEO of a major R&D organization with 814 R&D scientists. The other CEOs were still managing the same company as during their first interviews. It may be appropriate seen the size of the focus group and the interaction of these CEOs to have a short description of the four CEOs.

Characteristics of the CEOs participating in the Focus Group Research						
Life science R&D Firm	**CEO**	**CEO age range**	**CEO educational background**	**CEO experience**	**Number of scientists in R&D**	**Country**
C	CEO1	40-50	Science	Business development	approx. 800	Belgium
B	CEO5	30-40	Economics	Investment banking	approx. 200	Switzerland
R	CEO8	30-40	Engineering	Management consulting	approx. 30	Belgium
P	CEO15	30-40	Science	Chief Scientific officer	approx. 20	Belgium

CEO1 is a soft-spoken, experienced top manager with a highly developed scientific academic career which then changed to a business development position and subsequently to a CEO position of two life science R&D companies. He is known to interact strongly with all levels of the R&D organization and argues that most of innovative work comes from the 'bottom' of the R&D function and that that level should be highly regarded as to their input in innovation.

CEO5 is known by his collaborators as a highly intelligent, sharp and fast learner and although he does not have a biomedical background, he knows the language of science through his earlier research work in the social sciences. He has major experience in investment banking. His remarks are sharp and to the point and his interest in acting as an effective CEO of a science firm sounds sincere.

CEO8 has no bio-medical background and came from a major consulting firm; CEO8 showed sincere interest in the topic of research and has read the systematic review of the literature with great interest. It is clear from the communication with CEO8 that he/she likes to reflect on his responsibilities and his/her job and – during the interviews with CEOs – was the only CEO who argued that complexity reduction is not necessary and eventually may lead to flawed decision making.

CEO15 is known as a very efficient manager who grew from the R&D group of his/her company. His/her collaborators respect his/her because of his/her dedication, interest in R&D activities and continuous wish to foster communication within the company. He/she argues that, as he/she grew from R&D, it would be a mistake as a CEO to keep on meddling with the science as this 'blurs' his/her vision for the future.

The size of the focus group

According to Morgan (1997), the size of a focus research group is based upon as well 'practical and substantive considerations that help to clarify the basis for the rule of thumb size that specifies a range of 6 to 10'. According to Morgan, a focus group below 6 may be difficult to sustain a discussion, above 10, it may be difficult to moderate one. However, Morgan argues that 'one should not feel imprisoned by either this low or upper boundary' and that 'groups of 3 highly involved participants would have been unmanageable at size 6'. In the case of CEOs who are individuals with very clear point of views and are capable to articulate their points of view quite strongly and with conviction, the presence of 4 CEOs was considered a focus group size that was manageable from the point of the moderator. Above 4, and certainly at a group size of 6 or higher it would become quite difficult to moderate a group of independent, mature and very articulate – opinionated – individuals.

Determining the interview content

According to Merton et al. (1990) the goal is 'to construct an interview that covers the particular topic at hand while generating observations that satisfy the four criteria' mentioned above. Because focus group meetings generally last about 1-2 hours, it is recommended to develop a guide that structures the activities with the focus group (Morgan, 1997). According to Morgan, the most common form of guide is based directly on questions because 'the very act of asking questions signals the moderator's basic control over the content and direction of the group's discussion'. Therefore the focus group was informed about the agenda that would guide the discussion. The CEOs were informed before the start of the meeting as follows:

- Step 1. The interviewer presents the data of the research obtained via the CEO interviews in a condensed fashion as to allow the CEOs to become informed about the conclusions. The time foreseen for this session was 10 minutes.
- Step 2. The CEOs are asked whether the conclusions obtained could be supported by their own experience and whether they resonate with their experiences. The time foreseen for this discussion was 30 minutes

- Step 3. Finally, the CEOs were asked the following plenary question: 'What is in your opinion the most important challenge for you as a CEO in leading R&D in a life science R&D firm'

It was agreed with the CEOs that the overall sequence should be respected. All CEOs agreed with the proposed guide.

Meeting site

According to Morgan (1997), the site is a particularly import aspect of focus group research, as the site 'must balance the needs of participants and the needs of the researcher; there is little use for sites where participants will not be comfortable or where it is not possible to record the session'. Therefore, it was decided that the meeting should take place in an environment that is suitable for the elite level of the interviewees. The Faculty Club of the University of Leuven was selected because it was at an appropriate distance from the headquarters of 3 firms and for one CEO to fly in directly from the airport. The meeting started at 7 pm with a short reception for each other to meet, followed by a light dinner. Afterwards the CEOs were informed about the guide as discussed above.

Recording, videoing and transcription

The discussion was recorded using an Olympus LS11 digital recorder but was not videoed. The text was transcribed word by word but, because of the complexity of the interaction, it was reproduced in a condensed way in order to extract the data while the audiotape was also used as the source of content analysis. It was (re)listened several times to understand and appreciate the dynamics of the interaction. The meeting took 1hr and 20 min.

Data analysis

The transcript was analyzed as follows. The transcript was introduced into a tabular overview in which the CEO comments (CEO5, CEO15, CEO8 and CEO1) were introduced in chronological order and accompanied with comments from the interviewer (3rd column).

Appendix K. Focus group research observations

CEO	CEO comment	Comments by focus group moderator
CEO5	One of the other important parts of the so-called simplification of the idea is that it goes beyond the ability of the CEO to understand the complex data coming out of R&D but even more importantly, that it allows: - The selling of the idea to the shareholders - The selling of the idea to the market - The selling of the idea to the employees and to be able to rally people behind the idea. In other words you can only drive the idea if you can make it simple, because if you describe it in a detailed 'raw' way, people will get lost and loose the value of the idea	*CEO5 reconfirms the statement made during the interviews of CEO2 that the complexity reduction step not only serves to balance the absorptive capacity of the CEO, but also the latter's narrative using the transformed version of the complex R&D knowledge as the basis for story telling inside and outside of the firm*
CEO15	Well there is another important characteristic to that simplification process, in that it forces the R&D groups to focus on what they are actually doing: by forcing them to put the knowledge in simpler terms , it generates focus: i.e. what are we doing and what is the objective of what we are doing in a way that 'OK now I see it...' What I have also found is – and I grew out from the R&D myself – that by doing so - the CEO is not only capable to understand the science that takes place but even more important to ask the right questions to R&D and it's that training exercise that is very important – It is also one of the big challenges of a small company and that is to keep the team motivated because this is a good driver because bonuses is only a short term driver – one of the motivational drivers is also to be challenged	*This is also corroborated by the R&D individuals who argue that it is important to keep the link between their research and the larger context in which it is conducted. Knowledge reduction is therefore also a 'sense making' process for R&D. The comments made by CEO5 and CEO15 show the importance of the concept of knowledge reduction. It seems to be an important instrument in the CEO's arsenal of management techniques to run his firm and involve R&D.*
CEO1	A CEO can also not be too dominant especially with scientists...	*CEO dominance was also referred to as a CEO characteristic that is incompatible with life science R&D firms as corroborated by CEO14. The need for 'CEO science understanding' was raised by R&D executives but not clearly defined (see Chapter 6). Although gender impact was not a focus of the research, the CEOs considered this an important parameter for further investigation.*
CEO15	That's true because you will suffocate them	
CEO8	...some R&D executives require basic understanding of the CEO with respect to the science. That is a very low requirement... they are more looking for brainpower than for scientific insight	
CEO15	How many female CEOs were represented?	
CEO1	55% of all employees in life science are women...	
CEO8	In our company alone that is 80%...	
CEO15	The reason is that probably you will find a gender difference	
	At this point the moderator changed to the topic of trust as it appeared during the interviews with the R&D Executives	
CEO8	The question is to know about what trust we are talking. Is it trust in the CEO but in what?	*At this point CEOs refer to the balance between trust and challenge as was raised by R&D executives during R&D interviews. The trust- challenge-distrust relationship seems to be a sensitive topic between CEO and R&D. According to CEOs, challenge is required, while R&D executives agree with the positive aspects of challenge but question when challenge starts to create the perception of distrust.*
CEO1	Making sure that he is the right person to bring in the money, to approach the market... for the company to survive Talking about trust there is a complementarity between the level of trust and the knowledge that resides in the CEO	
CEO8	The trend is in trusting the CEO doing the right thing... it's not necessarily saying that the CEO is trusting me I think this is the most complex issue... Trust of the CEO	

	towards the team – I find it also very normal to challenge people that when you come along and you start asking questions: can you show me the data – but some people interpret this as a lack of trust – some people really think that if I come with this it should be fine and why question it?	
CEO1	There is a very thin balance between trust and control – just from my experience : we were taken over by (name of company) that's a company – a multinational – typically where .. they manage not by trust but by control. They manage ... by definition, they do not trust anyone... and typically, so my boss who was a senior VP at (name of the company), when I was telling him, he was at least checking data related to numbers or figures with five other colleagues to make sure whether this is consistent	
CEO8	What I find a bit difficult, it's almost checking...	
CEO1	That is , that's how they work... by definition, they don't....trust	
CEO8	That sounds – that is very clear to me as being wrong...that if somebody is telling you something you're gonna check it with somebody else	
CEO1	That's typically... in these firms	*It is clear from the discussions with the CEOs that the concept of trust is a difficult concept and that it is not clear where the balance can be found between trusting R&D and let R&D proceed and where the CEO should become involved and to challenge thereby risking the development of feelings of distrust within R&D. CEO8 considers challenge a 'conditio sine qua non' for dealing with R&D.*
CEO8	For example, a person that we fired – (we lost every single client) because we had quality issues and quality issues that she/he was hiding and frankly, I fired her/him and he/she literally said I will never work anymore for a CEO who does not trust me a 100%... and there it was very clear that I personally went overboard in trusting her too much and still it was not sufficient to her... so therefore I find this trust to be a very complex hmm... it's very difficult to accept data and be offered data by R&D with the statement 'take it at face value'...	
CEO15	From my experience, in my company which is a high research company, so there is not that much routine... I had similar issues; somebody masked results, but what I have noticed in our company what helps I believe is that I never challenge what comes out...I challenge it up front...we do it with a project management system: when we have investment review. Before the project is actually conducted and people are not personally attacked by it...because you discuss every possible outcome, the whole experimental design. We do that as a team and the result that comes out is nothing 'personal' anymore; if you say ok... and that helps what I found certainly with very difficult experiments..it's a complex matter and that people did not find personally attacked if you are challenging up front; were the	

	statistics right? .... but really take the challenge upfront (instead of after the facts)	
CEO8	Let me give you the following example, there is a business developer who comes to me and says .. you see I talked to a number of CROs at this conference and a big competitor and they told me that they are 10 % cheaper then we are... I want us to drop our prices.. what do you do?	
CEO15	If you are indeed not getting new business in.. something is wrong... In general, I remember at some point a business developer in our company was coming back saying you know... we definitely have no competitive prices.. and yeah it was easy to trust him...because we were not getting the business in...something was wrong...but the technology was strong...it was probably overpriced..	
CEO5	It's a common conversation with sales lower our prices it is all about the margin...	
CEO8	We were getting business in...	*The concept of challenging is not only a matter of the act of 'challenge' itself, it is also a matter of 'how' the challenge is taking place*
CEO5	Maybe I could throw another element in here. I think it's really ***how*** you have the conversation... its not about what you are challenging it, it really is ***how*** you bring it... and there is really a communication style element to it... and to make it even more complex .. what I learned he last year there are major cultural differences and the Flemish culture is really on the one end of the spectrum – it's actually similar to the Japanese culture believe it or not... and you have another dimension of sensitivity to the question how the questions get asked.. You have to be very polite that is important and especially as a CEO, if you ask a question it is really amplified in the Flemish culture...If you ask the same question in the United States, in Germany in the UK you get very different responses – so that was really an interesting experience to me culturally, particularly in Flanders .. You have to be very polite...	
CEO15	Yes, I saw that as well ... well, I have not worked as a CEO in the States but I led an operational team in the States and for me it was a night and day difference compared with Belgium – I found that the average scientist in Belgium performs at a higher level but I believe that ... they are more negative ... they love to complain, they love drama, and their commitment to the company is lower than what I observed in the States.. In the US you are in the company, you believe in it..., you go for it.. you don't constantly scrutinize the decisions and I believe that is completely different here in Flanders... The whole team wants to think through the entire process.. and scrutinize every single component of it.. whether they are in the right position to do so, it does not matter... they all have their opinion on everything...every single topic that happens in the company. In the US, I did not experience that... So for me it was much easier to lead a team in the States than it is here in Belgium...	*The concept is trust disruption may be culture driven*
CEO8	I think it also differs among people, I have people where I can be extremely straight and ask questions and then there are other people where I ..	
CEO15	Yes I agree, I do not want to generalize but I found in the States everybody was more inclined to go along with the company – wasn't questioning every single thing all the	

	time... and I think it's the Flemish mentality sitting beneath our church and watching what everybody else is doing... and criticize what everybody else is doing..without acting ourselves.. and to some degree that kills innovation and I think that is also linked to the company culture as well..	
CEO5	The major challenge for a CEO of a life science R&D firm is focus, focus because we have so many great people in our organization and excellent scientists that it is difficult to choose from the different opportunities from creative bright minds in the firm... Excellent ideas	
CEO1	I think that is a challenge for most of the R&D driven firms biotech companies because a/ they are limited by their financial resources and b/and the same time, so the focus, and at the same time making sure that what they do that they are 'leading'... that you maintain your competitive edge which by definition means that you need to continue to innovate and that's ... finding the right balance	*Focus is difficult seen the quality of the people in R&D. This is a re-confirmation of the statement made by CEOs that the focus is on maintaining the firm's competitive edge, and not allowing R&D to explore non-core academic) routes (see Chapter 4)*
CEO5	Yeah, it's really tough, a tough balance	
CEO15	Yeah me too...	
CEO1	Yeah I agree with that...I agree with that.. Within the whole context of – what is it...	
CEO15	I think it's focus, I believe it... a problem of early stage when you have many choices but once you have the focus...is clear, we know what to do and..where we need to go. I think it's motivation... because initially R&D teams will complain well it's unclear from management what we are going to do which direction, that direction etc... they want to see that focus and they need structure and focus and once structure and focus is there, then the next step how do you keep them functioning at such a high level... Because once the focus is there the teams tarts to grow, and certainly people at the very high level, they hate it if there is too much routine... What I am a firm believer in and I saw it from the other side, (the experience I had in the US) the company I worked for had an extremely open policy and very open communication, we knew how much money there was on the account, you new exactly what the CEO was doing, why he was doing it...we had a very open communication, and that really led to commitment... I knew exactly what they were doing... and saw exactly OK that is how they approach it...and saw commitment because I was learning at a high speed and I was learning so much and I am translating that this to the company right now... I think it is the learning that is motivating. They know exactly I am at (name of conference), these people are investigating this and this and that and when I come back from.. I go to outside meetings , e.g. to a course on reimbursement , but upon my return I share all that information with them (R&D) not in the largest detail and not on every single day..otherwise nothing gets done but they really feel like there is nothing hidden, everything is out clear in the open, everything is on the table and they see as well that I also have to do my daily jobs in terms of finance, making sure the bills get paid...and all of that stuff and ...they are committed..	*Although not explicitly raised during the CEO and the R&D executive interviews, CEO15 raises the issue of R&D motivation. CEO15 argues that R&D motivation may be ignited through a culture of transparency, that generates commitment from R&D. The arguments raised by CEO5 indicates that the concept of CEO commitment has its counterpart in R&D commitment. Although it is very premature to argue, but is an interesting concept in that the CEO role behavior such as CEO attitude etc. may have /may need their respective R&D counteracts in order for innovation to flourish, such that for example CEO commitment triggers R&D commitment and vice versa*

CEO5	I do something similar. I write a CEO blog when I go to for example conferences, the things I see .. how others are doing...we share on a quarterly basis all our financials.. so we have an open employee round table – we try to keep transparency with the employees on the things that are happening... but there are two other things that appear and we try to do: one main thing that I try to do is around purpose: the question of why? Why are we a company, what are we trying to do...what is the bigger mission for us, what is the purpose? It really is in our case of making a difference in terms of treating patients.. how we want to bring (name of product) everywhere in the world, make it easy, reproducible to change how researchers are developing drugs and the focus on (therapeutic area): what makes a difference... we had (name of person) came over and give a very personal speech of himself as a patient and what is happening in (therapeutic area) and explaining why what we are doing is making such a difference.. it really rallies the employees around a common purpose... and repeat that all the time... so that is one key element The second key element is the 'fun factor', so we actually have as one of our core principles that people should work hard and have fun.. measured actually...it is one of the performance metrics...are you having fun yes or no?.. we try and celebrate small victories so we have many parties, dj's at the company...and so we really try to keep that chemistry inside the company...that is fun, if there is any negative talk we try to react immediately on it and put the spotlight on it...to keep this chemistry, this excitement	
CEO15	I think key, key is communication and you often tend to forget about it...if it gets extremely busy...you tend to cancel a staff meeting and you can do it once...you can do it twice	
CEO1	I think the larger a company is of course...the more difficult that becomes	
CEO15	The more difficult this becomes	
CEO1	The more challenging it is... but for me there are two things where I wanted to.. for example, the scientist who determined what is going to in the pipeline which are for me very key people just make sure that they stay connected with what they do is creating value and that is what I always try to do...and showing results of our business partners Ok so they claim ownership of that – that they are very much disconnected from where the value in the market has been created...	*Again, CEO1 reaffirms the need for focus for R&D, such that R&D is not distracted/disconnected from the core objectives which is to conduct R&D with a market objective*
CEO1	Another way of motivating is well business having, having... business deals. We had two major business deals whereby – I would not call them service deals – but whereby they had to deliver and being part of it...having been able to contribute to that was always very motivating because they worked I teams with other companies and they discuss the issues and problems , it is seen as motivating	
CEO5	Valuing their work is really important – there are small things that you can do like for example in December I went into the pilot line and there I made a (name of product) together with the team...so they had to explain to me all the 39 steps... putting this product together...	

	and so this team spent a half a day making that product with me... you show that you care about it...what they are doing, you show that you are there to support them.. these small things can take you so far way..	
CEO1	That is what I spend quite some time in spending time with all levels within the company... for example people working in the (name of unit), really I valued them what they did...very much... And I always sensed that for them that was highly appreciated but very motivating... Again, it is about valuing their work, their contribution to the company...wherever you are (in the company)	*Here the concept of CEOs operates at all levels emerges again*
CEO15	I saw that in the States in a company of 60 people: every other week he CEO walked around and talked to almost everybody in the organization: just ask what are you doing, and not to scrutinize, not at all, purely out of interest, interest in you as a person and valuing what you are doing for the company, that is such a boost – every- body was talking about it.. that is one point and I think – that is the point that you make (pointing to CEO3) the external business and service I noticed that people are a bit slightly more motivated if it is an external project then an internal project – because it's their name on the report and they will go that extra length to ensure . they represent the company...they are absolutely proud of that...	*Talking at all levels*
CEO1	We did that to (referring to the all-levels visits of the CEO) every two months...	
CEO15	We do the same – we call it a corporate day and in the morning we have the management presentations (financially etc).. feedback from the board and so forth...and in the afternoon, small team building...	
CEO8	In our company, we are bit different we are xx people, In my case the biggest challenge is to keep up with the science, there is a lot of advancement in the field.. so many things come out and actually, they see the (scientific) paper and it has immediate impact on what we do... so trying to follow that ...	*Here the topic of 'CEO has expert knowledge' reappears*
CEO1	.. but how far do you go in that because you have to make choices everyday and when you see all these new ... you know ... on the one hand these are threats or opportunities...	
CEO8	For me it is related to the vision – my company is x year in the running and the same vision still stands... the strategy can change a little – the vision is on which mountain do you want to stand and strategy is which road will you take.... and that is very 'public' and from that we cascade everything down (to the finances). We also have a very flat organization – a leadership team of 8 people...there are just 2 layers...the team knows exactly how much cash we have and so on... The other people I must say I would tell them – they are rather more interested in the science, the status of the projects, what clients think... sometimes scientists argue that it is better for them not to know how much such a test costs that we are conducting... My experience is that they (R&D) are not so much interested in for example the cash status...that is not what they are typically interested in...	The concept of CEO-attention re-emerges as part of the discussion how and which R&D project to support. The focus that underlies the long-term view.
CEO15	You have to judge your team very carefully and see whether they have the mental power to really put this	

	into the right perspective, because some people may not be able to cope with it...depending on certain situations your company is in, I am not putting everything on the table... I	
CEO15	know exactly what I want to convey and am definitely holding stuff back as well, because you do not want your team to be worried..	
CEO8	We have cash for another (x) years which for a biotech company is quite a lot... but even that makes some people very, very nervous... sometimes we inform our people ahead of a press release of what we plan to do	
CEO15	It is extremely motivating that you share the information with the people before it actually goes public	
CEO8	.... but that is quite a risk isn't it?	
CEO5	Communicating means that sometimes you need to keep things internal to the company	
CEO1	Especially because it is a small world and everyone knows everyone...	
CEO15	That is the case in the US as well... it is a very small community...	
At this stage a discussion develops on the technical and commercial value of therapeutic areas and opportunities and the moderators interferes and stops the discussion to keep the focus on the topic and specifically on the topic of 'knowledge' (as the need for knowledge was a frequently recurring topic of discussion with the R&D executives)		
CEO8	You do not need to understand everything but at least to the level that you are capable to have discussion...with the scientists, with the CSO. Often things can change quite quickly and then you need to understand what the implications are and putting it into the perspective and what the companies would like to see or not see;: what are the technologies that are available. It is always surprising how things that are standard now were considered not possible 12 months ago. There are so many technologies coming online...and it goes so quick...that you need to see quickly the implications...	
CEO8	so all these things actually come into play in the business discussions and how do I figure out what information I can disclose or not...	
No further discussion of knowledge is taking place as was observed during the CEO interviews. It is not on top of their mind set. If you would be asked to identify a CEO for a life science R&D firms, what characteristics would you identify as crucial? Is it knowledge? Is it brainpower?		
CEO8	By definition, I do not think there is a key thing...if there is a key thing it is probably the multi-functionality - there are lots of different things	This section addresses the requirements of a CEO of a life science R&D firm. Again, the concept of learning new R&D knowledge linked to their absorptive capacity is stressed. In addition CEO5 stresses the 'learning agility' and not necessary the 'learning ability' of the CEO. In addition, communication, emotional intelligence, motivation-ability, knowledge of the market, or the capability to translate this knowledge in a simple way.
CEO5	Well I think it is one of the things that we talked about... at least from my personal perspective I would say 'learning agility'; the agility to learn, un-learn and re-learn... because un-learning is pretty important in a world that changes... this learning agility Communication... these are general themes, not really specific to life sciences...	
CEO5	General leadership abilities, emotional intelligence, ability to motivate the people; I do not know that if I were a board member that I would mandate that the CEO has to be a scientist, what I think is much more important is that the CEO can understand the market	

	and translate that into a simple way, communicate to shareholders; so there must be some base level of translation, but really understanding all in great detail is not necessary...	
CEO15	For me the situation was different as I was leading the team scientifically, before I became CEO, and I noticed that I had a much clearer vision, the less I got involved in science, the involvement of a CEO in science should be from a distance, because the more close you are involved the more blurred your vision becomes… you are sidetracked... I think it is really ... I think emotional intelligence is very important, bringing in the right people at the right point in time and you of course need to have market knowledge and know your business really well... and also understanding that a company is evolving ...and the team at the beginning should not be the team at the end and you have to make sure you are capable to identify a weak link running around and everybody sees it, the CEO sees and does not act upon it...it's killing...because everybody gets de-motivated.. Also if a company changes you need to change the company's environment.. always be one step ahead...Ok this is where we need to get to, not right now but we need to prepare ourselves… for example retrain your people Also excellent people skills are necessary... And also offer trust so that you should not be involved in every little factor..	*According to CEO15, dis-involvement in the science is an important behavior in order to create a clear vision for the future, the creation of a certain distance from the science*
CEO1	Yes you need to put these things (the science) in the grand scheme of things	*The commitment theme is an important role behavior of the CEO, illustrated by the hiring of the right people at the right time. A clear view on the future (CEO attention) and focus and trusts towards the R&D function.*
CEO8	That is what I meant there is no single key characteristic you need to be distinctive in, it is almost the opposite, you have to be in a lot of things at least good, but if there is one thing among these things in which you are not good in, I think there is an issue...	*According to CEO8, all the above characteristics seem to be important as a 'whole', while the absence of one characteristic may be detrimental, or should be compensated by another member in the top management team.*
CEO15	Well if you know your own weakness then make sure there is somebody who is there with the strength to balance you weakness...for example, if I am weak on the science part of things, get a good CSO...	
CEO8	But again, if you are not good on the science you have an issue, if you are not good at the people level you have an issue...if you are not good in making decisions you have an issue, if you are not goof in communicating you have an issue	*However, CEO8 is still not convinced if the knowledge of the scientific principles is not present in the CEO, then 'you have an issue'. In other words, the concept of 'knowledge' remains a discussion topic among CEOs and R&D executives*
CEO1	Yes but these (manufacturing) guys are excellent in operational capabilities...here you need of course – we are all R&D driven... high risk, capital intensive..	
CEO5	What are the most successful CEOs in the pharmaceutical industry? The current CEO of (name of company X in pharmaceutical industry) is the former CEO of (name of company in food industry). He has zero life science exposure....	
CEO1	But maybe X, that is not a life science company anymore....would this work in a small biotech start-up where you put someone with no experience with the start-up, dealing with VCs, managing expectations,	

Is there a characteristic that differentiates a life science CEO from let's say a manufacturing CEO?		
CEO5	Could you imagine an internet CEO joining the biotech industry? He knows the VC's, the start-up culture etc...???	
	Silence	
CEO8	I don't think it matters a lot	
CEO1	I think it all comes down to personality to what the person is....	
CEO15	I think that is true...	
CEO1	Our company was once managed by a CEO from a major multinational coming in managing the small R&D company of 35 people, it was a disaster... no affinity with the science...it killed him...he even looked at them as if they (R&D) were wasting money...	
CEO5	They need to have the learning agility....one advantage of coming from the life science industry is that they have relationships, the network,	
CEO1	I think the network is very important in this business...	
CEO8	I think that is everywhere he?	
CEO1	Yes, but the time you need to invest in building that network is .	
CEO8	I think the other thing is flexibility, the ability to 'move around' and probably a little bit more stress resistant...and being comfortable to dealing with lots of uncertainties	
CEO1	Each of us is exploring unknown territory...	

Appendix L. Procedure for the interviews of the R&D executives

The research that investigates the role of the CEO as seen by R&D executives is also exploratory. This is justified by the fact that it is a continuation of the previous research that investigated the role of the CEO as seen by CEOs. The main argument to define this research as exploratory is that there is still 'little or no scientific knowledge about the group, process, activity or situation they want to examine but nevertheless have reason to believe it contains elements worth discovering' (Stebbins, 2001). That little is known about the perception of R&D executives about their CEO's role in innovation was shown by the review of the literature: no empirical study was identified in which R&D executives' perceptions about their CEOs' role in innovation was studied. The continuation of a structured interview based exploration with R&D executives can be argued as follows:

- first, the first part of the research was an interview based exploration. It would be difficult to defend the use of another method when both research streams focus on CEO roles, either *used* by CEOs or *perceived* by R&D
- second, if one of the objectives of the research is to explore differences between the roles that CEOs use to describe their role in innovation and the roles of the CEO as perceived by R&D then it is required and necessary to use identical methods.

It was therefore decided to continue this part of our research using a structured interview based exploration.

Interview procedure

Selection of R&D scientists
Each CEO who joined the research project agreed for his /her key R&D managers be interviewed. The list of the 39 R&D executives selected by the CEOs are listed in Appendix M. The R&D executives were approached individually and informed about their selection by the CEO for a research interview. A date and place for the interview was set and an agreement was reached on the duration of each interview.

From R&D research questions to R&D interview questions
As it is decided to proceed with this research by means of structured interviews, interview questions should be developed that allow the research questions to be answered. The interview questions that will be asked to R&D executives should mirror the interview questions asked to the CEOs. For example, while the question asked to the CEO: 'What do you think are the attributes of the role of a CEO in innovation in a life science R&D firm?' requires the CEO to respond with his/her view about his/her role, the same question, when asked to the R&D function, explores how the R&D function perceives the role of the CEO. Other interview questions which were asked to the CEO are slightly modified such that the question is not asked *to* the CEO, but to R&D

executive *about* the CEO. The questions that will be asked to the R&D executives are included in the table. The questionnaire is added below.

Contrasting the interview questions		
Q	**Question as used in CEO interviews**	**Question to R&D:**
Q1	What do you think are the attributes of the role of a CEO in a life science R&D firm?	What do you think are the attributes of the role of a CEO in a life science R&D firm?
Q2	What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm?	What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm?
Q3	What is in your opinion the most important driving force for R&D innovation in the organization and why?	What is in your opinion the most important driving force for R&D innovation in the organization and why?
Q4	How do you create a climate of innovation and why?	How **does he/she** create a climate of innovation and why?
Q5	Is an innovational climate important even in R&D firms which should be, by definition, innovative because of the nature of the work?	Is an innovational climate important even in R&D firms which should be, by definition, innovative because of the nature of the work?
Q6	How much time and effort do you make available to obtain information from your R&D team in percentage?	How much time and effort **does he/she** make available to obtain information from your R&D team in percentage?
Q7	How are new ideas developed in R&D?	How are new ideas developed in R&D?
Q8	How do you identify new ideas in your firm and exploit those ideas?	How **does he/she** identify new ideas in your firm and exploit those ideas?
Q9	Are you actively looking yourself for new ideas in the organization?	**Is he/she** actively looking yourself for new ideas in the organization?
Q10	What are your driving factors to invest in, make available resources and support R&D?	What are **his/her** driving factors to invest in, make available resources and support R&D?
Q11	How do you as a CEO actually increase the output of R&D?	How **does he/she** as a CEO actually increase the output of R&D?
Q12	What are your incentives to stimulate innovation in R&D?	What are **his/her** incentives to stimulate innovation in R&D?
Q13	How do you live with and manage the risk associated with R&D?	How **do you think does he/she live** with and manage the risk associated with R&D?
Q14	How do you bridge the gap between the scientific/ biomedical knowledge in R&D and your (general management's) knowledge?	How **does he/she bridges** the gap between the scientific/ biomedical knowledge in R&D and your (general management's) knowledge?
Q15	With whom and how frequently (times/w, m, y) do you actually discuss R&D, and why?	With whom and how frequently (times/w, m, y) **does he/she** actually discuss R&D, and why?
Q17	To what depth are you involved in the NPD discussions and why?	To what depth **is he/she** involved in the NPD discussions and why?
Q18	What is your role in advancing new product development?	What is **his/her** role in advancing new product development?
Q19	How do you describe your role as CEO in R&D vs the role of your CSO?	How **does he/she** describe your role as CEO in R&D vs the role of your CSO?
Q19	Who takes R&D decisions and why? (	Who takes R&D decisions and why?
Q20	Who decides on the final product design and why?	Who decides on the final product design and why?
Q21	Who is the most important driver in new innovations in your firm?	Who is the most important driver in new innovations in your firm?

Q22	Have you seen CEOs who were particularly effective in driving R&D, and why do you think they are?	Have you seen CEOs who were particularly effective in driving R&D, and why do you think they are?

Content analysis

The interview procedure was identical to the procedure followed for the CEO (pilot) interviews (approach, confidentiality, recording, transcription). Each theme that emerged during the interview with the R&D executives was analyzed using the same primary/secondary node structure used for the transcript analysis of the CEO interviews and assigned to

- either an a priori literature based theme (CEO attitude: 'ATI attitude', CEO attention: 'ATT attention', CEO commitment: 'COM commitment', CEO involvement : 'INV Involvement' and CEO innovativeness: 'INN Innovativeness') or
- to a theme that emerged from the CEO interviews (CEO-OTH1 to 53)

If new themes would emerge that could not be assigned to any of the a priori themes and the 'CEO-OTH' themes, they were codified as 'RD-OTH1', 'RD-OTH2', 'RD-OTH3' etc., in analogy with the other roles that emerged from the interviews of the 15 CEOs (and which were previously identified as CEO-OTH1, 2, 3 ... 53).

Arguments for a pilot study

There are several reasons why a pilot study is worthwhile:

- first, the pilot study is needed to obtain a 'feel' for the interview of high level industrial scientists: how will they respond to academic research that explores their relationship with and attitude towards their CEO?
- second, one of the inquiries that are put forward to R&D top management executives is whether they 'have seen CEOs who were particularly effective in driving R&D, and why do you think they are?'. It is important to observe the feedback from the executives to see whether this inquiry is considered inappropriate realizing that by answering these questions they may inadvertently judge their own CEOs?
- third, it is also important to observe and 'feel' the response of the R&D scientists when they are approached to discuss the role of their CEO. Do they respond openly and open up with their own ideas?
- fourth, it is also useful from the interviewer's point of view to look for an optimal interview style with R&D executives: would there be specific conditions that have to be met when interviewing top level R&D scientists?
- fifth, if R&D top management 'copies' the role descriptions offered by the CEO, and therefore does not offer an alternative view on the role of the CEO in innovation, is it worthwhile to proceed with the study before recruitment starts of R&D executives?
- sixth, alternatively, if the R&D top managers offer strikingly different views as compared with the CEO views, it may drive the R&D executive research into other avenues and potentially into an alternative methodological approach.

Cranfield UNIVERSITY
School of Management

Research project The role of the CEO in innovation
Researcher : J. Rosier – Supervisor Prof. K. Goffin

INTERVIEW QUESTIONS TO THE R&D EXECUTIVE

Place of interview .....
CE: .....
Time start .....
Time stop .....

Q1	What do you think are the attributes of the role of a CEO in a life science R&D firm?
Q2	What are in your opinion the major leadership characteristics of a CEO in a life science R&D firm?
Q3	What is in your opinion the most important driving force for R&D innovation in the organization and why?
Q4	How does he/she create a climate of innovation and why?
Q5	Is an innovational climate important even in R&D firms which should be, by definition, innovative because of the nature of the work?
Q6	How much time and effort does he/she make available to obtain information from your R&D team in percentage?
Q7	How are new ideas developed in R&D?
Q8	How does he/she identify new ideas in your firm and exploit those ideas?
Q9	Is he/she actively looking yourself for new ideas in the organization?
Q10	What are his/her driving factors to invest in, make available resources and support R&D?
Q11	How does he/she as a CEO actually increase the output of R&D?
Q12	What are his/her incentives to stimulate innovation in R&D?
Q13	How do you think does he/she live with and manage the risk associated with R&D?
Q14	How does he/she bridges the gap between the scientific/ biomedical knowledge in R&D and your (general management's) knowledge?
Q15	With whom and how frequently (times/w, m, y) does he/she actually discuss R&D, and why?
Q17	To what depth is he/she involved in the NPD discussions and why?
Q18	What is his/her role in advancing new product development?
Q19	How does he/she describe your role as CEO in R&D vs the role of your CSO?
Q19	Who takes R&D decisions and why?
Q20	Who decides on the final product design and why?
Q21	Who is the most important driver in new innovations in your firm?
Q22	Have you seen CEOs who were particularly effective in driving R&D, and why do you think they are?

Execution of the pilot study

The same firms introduced in the pilot studies for the CEO interviews were also selected for the pilot R&D interviews. The first pilot R&D study was conducted in the same firm where the first pilot CEO (CEO1P) was interviewed. The second pilot R&D interview could not be conducted in the same firm where the second pilot CEO interview was done (CEO2 P), because the firm went through a difficult time and appointments were continuously postponed. Therefore, the second R&D pilot study was conducted in the firm that could make its R&D executives readily available for an interview. This was the firm led by CEO2. The questions asked to the R&D executives of the firm led by CEO1P were questions 1, 2, 6, 10, 14, 18 and 22 because the CSO only accepted a 30 minute interview for each (see shaded area in the table above). All 22 questions were asked to the R&D executives of the firm led by CEO2 because the CSO allowed a full 1 hour interview with him/herself and each of his/her R&D managers. All interviews were conducted on the same day. In the first pilot firm, four R&D executives were interviewed each during 30 minutes while in the second pilot firm, 2 executives were interviewed during 1 hour each. All interviews were recorded, transcribed and analyzed according to the operational principles laid down in Appendix E. The number of transcript pages was 45.

Pilot interviews of R&D executives reporting to CEO1P

The R&D executives in the first pilot study consist of a chief scientific officer (CSO) and three senior R&D scientists who report to the CSO and frequently interact with the CEO (as confirmed by the CSO). The findings are divided in two parts: the first part presents the emergence of literature-based a priori themes) followed by a 2nd section that presents the emergence of new themes.

Primary/secondary node structure based upon the outcome of the final CEO interviews (cfr table) and used for the analysis of the (pilot) R&D interview transcripts
ATI Attitude
ATI1 CEO fosters a culture of innovation
ATI2 CEO fosters experimentation and accepts failures
ATI3 CEO fosters internal communication
ATI4 CEO fosters the exchange of diverse ideas
ATI5 CEO fosters external collaboration to increase internal innovation
ATI6 CEO fosters flexibility and adaptability
ATI7 CEO fosters learning in the organization
ATI8 CEO states that processes may stifle innovation
ATI9 CEO has an inquisitive nature: asking, listening, probing
ATT Attention
ATT1 CEO sets the direction/goal and vision in which innovation to take place
ATT2 CEO sets the focus and boundaries in which innovation to take place
COM Commitment
COM1 CEO hires selects and develops innovative leadership

COM2 CEO creates incentives and rewards for the R&D function
COM3 CEO prioritizes resources
COM4 CEO makes available human and financial resources
COM5 CEO empowers R&D to execute on new ideas
COM6 CEO creates hierarchical flat organizational structures for innovation
COM7 CEO reduces development risk by hiring expert people and developing options
COM8 CEO manages ideal cash flow for LFRD firms
INV Involvement
INV1 CEO challenges R&D for efficiency
INV2 CEO challenges R&D technically
INV3 CEO acts as sounding board
INV4 CEO interacts with R&D to solve technical problems
INV5 CEO is involved in NPD
INV6 CEO holds frequent formalized meetings with R&D
INV7 CEO is involved at the start of an R&D project and then delegates it
INV8 CEO comes up with new innovative ideas
INV9 CEO evaluates economic viability of R&D project
INV10 CEO picks up to R&D innovational opportunities
INN Innovator
INN1 CEO drives new product development in person
INN2 CEO takes control of every detail of NDP
INN3 CEO wants to transform/disrupt the market
CEO-OTH CEO Other roles
CEO-OTH1 CEO admits limited knowledge in specific R&D area
CEO-OTH2 CEO admits not driving innovation but rather the direction of innovation
CEO-OTH3 CEO interacts with R&D only in those matters he/she has personal knowledge in
CEO-OTH4 CEO should not focus on technology
CEO-OTH5 CEO stresses the importance of strong knowledge in the field of innovation
CEO-OTH6 CEO requires R&D data to be simplified for strategic decision and communication
CEO-OTH7 CEO wants R&D to step out of academic thinking
CEO-OTH8 CEO role model is knowledge based
CEO-OTH9 CEO aims to obtain respect from R&D
CEO-OTH10 CEO attempts to understand R&D expertise
CEO-OTH 11 CEO carries R&D through difficult times
CEO-OTH12 CEO considers it an advantage to be untrained in science
CEO-OTH13 CEO considers himself at a disadvantage as a non-scientist
CEO-OTH14 CEO informs R&D about the company's position
CEO-OTH15 CEO role model is business driven
CEO-OTH16 CEO wants to protect R&D from the mundane aspects of running a firm
CEO-OTH17 CEO acts as a role model for innovation
CEO-OTH18 CEO role is to link R&D to internal & external stakeholders
CEO-OTH19 CEO reduces risk by fail fast fail cheap
CEO-OTH20 CEO gets information from/discusses R&D with all levels
CEO-OTH21 CEO role in R&D is not different from CEO role in non-R&D
CEO-OTH22 CEO looks for the best possible management team
CEO-OTH23 CEO requires persistence and resilience in LFSR
CEO-OTH24 CEO argues that innovation comes from top down and bottom up

CEO-OTH25 CEO and CSO are innovative forces together
CEO-OTH26 CEO innovates by challenging the organization (time, costs etc)
CEO-OTH27 CEO argues that innovation also occurs outside R&D
CEO-OTH 28 CEO argues that R&D should always be one step ahead
CEO-OTH29 CEO educates the firm's environment
CEO-OTH30 CEO argues that value is as important as market
CEO-OTH31 CEO and R&D should have relationship of trust and confidence
CEO-OTH32 CEO should have firm belief in the product
CEO-OTH33 CEO considers patients as innovation drivers
CEO-OTH34 CEO needs to understands process/risks of R&D
CEO-OTH35 CEO needs to understand culture of science
CEO-OTH36 CEO needs to know how to lead scientists
CEO-OTH37 CEO's understanding of scientists is more important than being a scientist
CEO-OTH38 CEO should have some basic understanding of science
CEO-OTH39 CEOs of LFRD firms should not be dominant
CEO-OTH40 CEO needs bottom-up ideas in LFSR firms
CEO-OTH41 CEO top scientist/top business man/women is ideal
CEO-OTH42 CEO argues that simple messages make for flawed decisions
CEO-OTH43 CEO – not R&D - should simplify the message
CEO-OTH44 CEO should make sure scientists can remain scientists (and not become managers)
CEO-OTH45 CEO should be very flexible
CEO-OTH46 CEOs should be/act transparent
CEO-OTH47 CEO can prevent a R&D knowledge gap by growing from within R&D
CEO-OTH48 CEO teaches R&D about business
CEO-OTH49 CEO does not need to be a scientist
CEO-OTH50 CEO has no time to talk to the scientists in R&D
CEO-OTH51 CEO balances R&D vision with the Board's vision
CEO-OTH52 CEO challenges R&D and is challenged by R&D
CEO-OTH53 CEO knows how to challenge R&D because of his experience

Literature based a priori themes.

The theme of CEO innovativeness (INN) did not emerge from the interviews indicating that the R&D's perception of the CEO as innovator is aligned with the CEO's view that they do not consider themselves as innovators (as was observed during the CEO interviews). Three themes appeared during the interviews: CEO involvement (INV), CEO commitment (COM) and CEO attention (ATT). The R&D executives emphasize the CEO's commitment and attention, i.e. his/her hiring policy and the presence of a clear vision about the future:

> '*it was our task to give a realistic idea of what is feasible and not feasible, to give a realistic idea of the disclaimers to the R&D idea ...maybe that the interaction of the CEO, CSO and a number of other (R&D) people has to be installed to start thinking about strategically, how should the future of this company look like?*'

This is made clear through the statement 'CEO involves R&D into vision' (RD-OTH4-P; see other themes below). CEO commitment is perceived by R&D as the CEO's vision to increase the potential for innovation by creating flat organizational structures and hierarchies and the hiring of the right people:

> *'I think what a CEO ... (*should do is*) only two things: define a line of vision and hire the right people. .. what he needs to do is to make sure that there is at least a level of communication which people in the different departments feel involved'*

The commitment theme is also made clear by R&D executives who perceive the CEO as capable to 'bring in the money'. Upon the question whether they have seen CEOs who were particularly effective in driving R&D , they responded by arguing that these CEOs had a clear vision and focus. A concept that is linked to the theme of CEO attention:

> *'the CEO of (name of other firm), focused on making one thing happen... getting drugs in development... So that is something we expect from him....a clear kind of defined buy-in, the definition of the boundaries in which we can work...not exact but roughly...'*

RDE1P and **RDE4P** referred to the vision (CEO attention), organizational structures, hiring policies (CEO commitment) and CEO involvement. Only **RDE3P** referred to the CEO's attitude in leading a life science based firm. The reason for the absence of this theme with the other R&D executives may be caused by the fact that R&D executives assume their CEOs were selected by the boards to have the right attitude to lead a science-based R&D firm and consider this not to be worth mentioning.

Other themes.

There are 21 themes that appeared during the interview of the R&D executives that could not be assigned to any theme previously identified (they are listed in the table below - RD-OTH1-P to RD-OTH21P). When asked about the necessary attributes of a CEO of a life science R&D firm, the CSO responded that he/she should have 'trust and have confidence' in his/her R&D executives (RD-OTH1):

> '*the CEO has to provide confidence and trust in the CSO'* and
> '*It's a question of confidence'*

On the one hand R&D requires the CEO to show trust and confidence in its expertise but on the other hand they expect they can trust the CEO in taking their contributions into account:

> *'...the hope is that (*there is*) trust in the CEO ... to come to (*a*) reasonable collaborative teamwork and agreements'*

The concept of trust was presented by R&D executives as a bimodal concept in that trust exists either *in* the CEO *by* R&D and *by* the CEO *in* R&D. The trust of the CEO in R&D is linked to his/her willingness to accept failures while the trust of R&D in the CEO

R&D Other roles codes:	Other themes:	RDE1 P	RDE2 P	RDE3 P	RDE4 P	Comments
RD-OTH1-P	Trust by the CEO in R&D	+	nm	nm	nm	According to the Chief Scientific Officer , the concept of 'trust' is key in the relationship between CEO and R&D. This argument was made several times by the CSO during the interview and with visible affirmation.
	Trust in the CEO by R&D	+	nm	nm	nm	
RD-OTH2-P	CEO offers freedom to R&D	+	nm	nm	nm	The concept of offering freedom was used by the CEO of this firm; it is here reaffirmed by the CSO. The offering of freedom to R&D obviously is a sign of trust and constitutes an attitude of the CEO towards innovation
RD-OTH3-P	CEO has no time to talk to R&D	+	nm	+	nm	The time taken by the CEO to talk to R&D is indicative of his commitment (time and effort)
RD-OTH4-P	CEO involves R&D into vision	+	nm	nm	nm	Involvement from the viewpoint of R&D means that the CEO looks for R&D input to develop a strategy for the firm
RD-OTH5-P	CEO is approached with simplified data	+	nm	nm	+	This is a re-affirmation of the observation made during the interviews of the CEO that data are reduced in complexity when interacting with the CEO
RD-OTH6-P	CEO is involved in R&D projects for valuation	+	nm	nm	nm	The involvement of the CEO in project evaluation is part of the construct of absorptive capacity as was argued in the first part of the research
RD-OTH7-P	CEO has sufficient knowledge for R&D to feel comfortable	+	nm	nm	nm	The concept of knowledge takes a strange 'twist' when seen from the viewpoint of R&D: the knowledge of the CEO should be such that R&D feels comfortable discussing R&D with the CEO not necessarily for the CEO to take decisions
RD-OTH8-P	CEO is teached by R&D on the value of R&D	+	nm	nm	nm	Part of the comfort creation of the R&D function is to teach the CEO about the science
RD-OTH9 –P	CEO links all stakeholders to build a new product	+	nm	nm	nm	The CEO 'who links all stakeholders' is a new concept that appears in these interviews
RD-OTH10-P	CEO for a LFSRD firm should ideally be a seasoned scientist and a seasoned business man/women	+	nm	nm	nm	The concept of the ideal CEO from a viewpoint of R&D is a 'rare animal' who is not only capable to deal with the science but even more to extract the fraction from the science that can be used to create 'wealth'.
RD-OTH11-P	CEO is not aware about the gap in knowledge between him/her and R&D	+	nm	nm	nm	This is part of the knowledge discussions held in the first part of the research during the CEO interviews when 'CEOs argue that there is a gap right?'
RD-OTH12-P	CEO receives messages that are considerably transformed for him/her to assess their value	+	nm	nm	nm	Same as above

RD-OTH13-P	CEO does not need to know all the details about the scientific research that we conduct	nm	+	nm	nm	According to R&D a CEO should not be knowledgeable about all the scientific details. In other words, there can be a gap, as long as it can be bridged 'comfortably'
RD-OTH14-P	CEO may have difficulties linking the details of the science with the value behind them	nm	**+**	nm	**+**	See comments under RDOTH6-P
RD-OTH15-P	CEO is very approachable	nm	nm	**+**	nm	This comment was made in view of the personality characteristics, such that a CEO is not a distanced figure the scientists should be afraid of to approach
RD-OTH16-P	CEO may underestimate the complexity of scientific R&D	nm	nm	nm	**+**	Some CEOs actually do not understand the complexity of the science
RD-OTH17-P	CEO is not a scientist per se (he should have other qualities)	nm	nm	nm	**+**	The argument that the CEO acc. to the R&D function should not be a scientist is based on the fact that R&D would appreciate learning from the CEO about the place of their research and development work in the larger framework of the business
RD-OTH18-P	CEO need for involvement is company size dependent	nm	nm	nm	**+**	The R&D executive argues that the need for detailed knowledge depends on firm size, with the largest need for knowledge in smaller firms
RD-OTH19-P	CEO involvement is ok but not in my daily research work	nm	nm	nm	**+**	The argument that a CEO can be involved is accepted but not to the level that he/she starts to meddle with the R&D work
RD-OTH20-P	CEO talks to all levels of R&D	nm	nm	nm	**+**	This is confirmed by the CEO in the CEO interview in this firm who argued that he/she interacts with all R&D levels in the firm
RD-OTH21-P	CEO is genuinely interested in R&D	nm	nm	nm	**+**	The CEO is interested in the science no because he wants to understand the work of R&D

nm: not mentioned;

New themes emerging from interviews RDE1P to RDE4P

is linked to the concern of R&D whether the CEO will actually be willing to accept R&D failures. In other words, the R&D executives' concept of trust can be described as 'can R&D trust the CEO to trust R&D?' The concept of trust by the CEO in R&D explains the appearance of another theme of the CEO offering freedom to R&D (RD-OTH2-P):

'*he gives sufficient amount of freedom to the chiefs (*of R&D*)*'

Theoretically, the theme of 'CEO offering freedom to R&D' could be categorized either in the a priori theme of 'CEO attitude' or in the new theme of 'Trust by the CEO in R&D and trust in the CEO by R&D'. It was decided at this point of time to keep these concepts separated and to keep sufficient granularity in order to avoid the risk of 'burying' a potentially interesting concept as any re-assignment of subthemes can still take place at a later date during the research.

Other themes that appeared during the interview were the themes 'CEO has no time to talk to R&D' (RD-OTH3-P) and 'CEO involves R&D into the development of a vision' (RD-OTH4-P). Of particular interest are the themes that pertain to the concept of knowledge: 'CEO is approached with simplified data' (RD-OTH5-P), 'CEO should have sufficient knowledge for R&D to feel comfortable' (RD-OTH7-P), 'CEO is not aware about the gap in knowledge between him/her and R&D' (RD-OTH11-P) 'CEO receives messages that are considerably transformed for him/her to assess their value' (RD-OTH12-P), 'CEO is involved in R&D projects for valuation' (RD-OTH6-P), 'CEO does not need to know all the details about the scientific research that we conduct' (RD-OTH13-P), 'CEO may have difficulties linking the details of the science with the value behind them' (RD-OTH14-P) and 'CEO may underestimate the complexity of scientific R&D (RD-OTH16-P)

As was observed during the interviews with the CEOs, the transfer of complex R&D knowledge is accompanied by a transformation such that the CEO can absorb the knowledge. The CSO argues that the CEO should not be aware of the gap in knowledge with R&D and that R&D should feel comfortable in interacting with the CEO when discussing R&D data. In other words, R&D has to feel comfortable discussing science with the CEO and train him/her CEO ('CEO is teached by R&D on the value of R&D' RD-OTH8) in order for him/her to understand the science. This may lead to a relationship of trust between R&D and CEO, as was made clear by the CSO:

> *'I think as well it is the task of the CSO to explain as clearly as possible why the given (R&D) vision will be followed; so it is not like that the CSO has to expect that the CEO has a full understanding and a full scope and idea what it takes to become innovative... it's the task of the CSO I believe ... and the hope is that ... the trust in the CEO is there ...'*

Teaching the CEO about the science is part of the transfer of R&D knowledge. According to this CSO, trust shown by the CEO in R&D can be developed by teaching the CEO. This learning process leads to a CEO with an increased understanding of R&D conducted in his/her firm and to a R&D function who feels comfortable with the increased knowledge of the CEO. R&D therefore 'trusts' he/she will involve R&D in strategic decision making,

an ambition that is clearly articulated by this CSO. A number of granular themes appeared during the interview which are at first sight unrelated to the other themes such as 'CEO links all stakeholders to build a new product' (RD-OTH9 –P), 'CEO for a LFSRD firm should ideally be a seasoned scientist and a seasoned business man/women' (RD-OTH10-P), 'CEO is very approachable' (RD-OTH15-P), 'CEO is not a scientist per se (he should have other qualities)' (RD-OTH17-P), 'CEO need for involvement is company size dependent' (RD-OTH18-P), 'CEO involvement is ok but not in my daily research work' (RD-OTH19-P), 'CEO talks to all levels of R&D' (RD-OTH20-P) and 'CEO is genuinely interested in R&D' (RD-OTH21-P).

Conclusion

This first pilot study showed that the CSO and the senior scientists use role concepts that did not emerge when these questions were raised to the CEO. The concept of trust both *in* and *by* the CEO were clearly articulated by the CSO. However, whether this new theme will prove to be consistent in the final interviews will need to be explored. It was therefore decided that in the final interviews any reference to the theme of trust was to be avoided in order to observe whether this theme emerged 'organically' during the interview and should be considered a firmly held belief of the R&D executives or simply a spurious observation. The theme of R&D data complexity reduction, which was clearly articulated by the CEOs during their interviews, surfaced again during this interview with R&D executives. The theme of learning took a dyadic form whereby CEO and a R&D executive learned from each other. From an operational point of view, it was observed that the questions were sufficiently clear to the R&D executives. It was therefore decided to proceed with these questions into the next pilot study. The second firm, although introduced into this pilot research by accident because the originally selected firm could not allow the interviews within the projected timeframe, proved to an interesting testing ground for our research as will be shown in the next section.

Pilot interviews of R&D executives reporting to CEO2

The second firm is the life science R&D firm headed by CEO2 who received scientific training but left the scientific and academic community to become a 'serial' CEO of biotech start ups. He/she argues that he/she does not want to 'be told rubbish' and allows his/her scientists only a limited amount of time to present and defend their R&D data to him/her. This firm saw its chief scientific officer leave and the core of the innovational activities resided with two experienced and top level R&D scientists who reported temporarily to the CEO.

Literature based a priori themes

The theme of CEO innovativeness (INN) did not emerge from the interviews. On the other hand, the theme of CEO-attitude is used by both scientists: the CEO is the individual who 'should definitely enable innovation'. This is in contrast with the first pilot study in which attitude was not raised frequently if at all. This company clearly suffered from the absence of the CSO as the CEO was 'hardly capable to have meaningful discussions with the scientists' (see below under *Other themes*). The same applies to the

theme of attention, and both scientists find the long term vision of the CEO to be important:

> *'He or she should probably also manage the innovation in a sense that it needs to be controlled and directed against longer term opportunities or even shorter term opportunities'*

> '*I would expect some guidance for what the long term visions of the company and where the innovation framework really is'*

The concept of CEO attention is also made clear by the **RDE5P** who argues that CEOs should create long-term stability in the firm to allow innovation to take place:

> *'... it requires a certain long term vision and you need ... stability in order to make innovation work, mostly it takes a little bit more time (*cynical*) than a few quarters ... business changes, context changes so depending on good reasons there might be a reason to stop ... but small short term fluctuations shouldn't really impact the overall innovation...'*

RDE6P recognizes the heavy burden on the shoulder of the CEO but argues that he/she should be visible to R&D and show clear signs of interest in R&D without becoming too much involved:

> *'I do not think that a CEO should be involved in the day to day discussions and scientific content'*

At the same time his commitment should become clear in the hiring process, a concept that was also made clear by the CSO in the first pilot firm.

Other themes

The themes that emerged from the interview with the two scientists **RDE5P** and **RDE6P** are listed in table below (RD-OTH22-P to RD-OTH47-P). Among them, the theme that emerged again was the concept of 'trust'. Trust seemed to be a sensitive topic because during the interview with **RDE5P** and **RDE6P**, the theme trust appeared 6 and 10 times respectively. Trust was specifically considered as trust *by* the CEO *in* R&D.

> *'We lack that kind of trust relationship' and 'the CEO should trust the right people to delegate those detailed discussion'*

> *'you need to trust your people' (*i.e; referring to the CEO*)*

R&D Other roles codes:	Other themes:	RDE1 P	RDE2 P	Comment
RD-OTH22-P	CEO not only enables but also manage innovation	+	nm	This refers to the attitude of the CEO who is not only the manager but is also capable to lead the innovation (the company has no CSO)
RD-OTH23-P	CEO is involved in the operational aspects of innovation only	+	nm	This is a criticism by the R&D function about the distance of the CEO and the R&D function whereby the CEO only refers to R&D as an 'operational' department as any other department in the firm. In other words, the CEO is not capable to observe the particular characteristics of a R&D environment
RD-OTH24-P	CEO is not capable to judge the innovative character of an R&D proposal	+	nm	This is a fierce criticism of the R&D function
RD-OTH25-P	CEO does not trust his CSO and R&D	+	+	According to the CSO, the concept of 'trust' is key in the relationship between CEO and R&D. This argument was made several times by the CSO during the interview.
RD-OTH26-P	CEO does not have the scientific credentials to evaluate new proposals on its merits	+	+	See RDOTH26-P
RD-OTH27-P	CEO empowers the CSO to make decisions	+	nm	This is the criticism made by R&D that a CEO makes decisions that are in fact 'terrain' of the R&D function. It is also related to the concept of trust.
RD-OTH28-P	CEO is only suitable to think about budgets, timelines, deals	+	nm	See RDOTH23-P
RD-OTH29-P	CEO does not have detailed knowledge in the science	+	+	This is part of the knowledge discussions held in the first part of the research during the CEO interviews when 'CEOs argue that there is a gap right?' see RDOTH11-P
RD-OTH30-P	CEO receives highly transformed R&D message that does not make any sense anymore to R&D	+	nm	idem
RD-OTH31-P	CEO will more easily say 'no' to a project the more innovative it is	+	nm	This is linked to the criticism of R&D that the R&D function is considered an operational piece of the organization and innovative ideas disturb the 'balance' within the organization and therefore may consume resources that will 'not pay off'. This is a visible sign of 'dis'-trust.
RD-OTH32-P	CEO refuses R&D to take decisions	+	nm	See RDOTH27-P

RD-OTH33-P	CEO acts very intimidating and dominant towards the science community in the firm	**+**	**+**	This observation was also made by the R&D function in the first pilot R&D interview where the CEO is 'very approachable' and does not act as a dominant and intimidating individual
RD-OTH34-P	CEO takes a step back and tap into the brain power of the organization	nm	**+**	This R&D statement refers to the CEO who uses all the brainpower in his/her firm to come up with new innovative ideas, work-procedures etc.
RD-OTH35-P	CEO is very approachable	nm	**+**	Same as in RDOTH33-P
RD-OTH36-P	CEO communicates the firm strategy to R&D	nm	**+**	The sensitive link between R&D and strategy. This is linked to the concept of trust as the need for involvement of R&D in the development of firm strategy is a sensitive issue in R&D
RD-OTH37-P	CEO involves R&D to develop a strategy and vision for the firm	nm	**+**	Same as RDOTH36-P
RD-OTH38-P	CEO of a LSRD firm does not run the firm as a finance manager	nm	**+**	Same as RDOTH23-P
RD-OTH39-P	CEO understand the risks and challenges of life science R&D	nm	**+**	If the CEO does not understand the science he/she should at least understand the risk of new product development in a life science firm
RD-OTH40-P	CEO is very isolated from R&D	nm	**+**	The time taken by the CEO to talk to R&D is indicative of his commitment (time and effort) – see also RDOTH3-P
RD-OTH41-P	CEO has not time to talk to R&D	nm	**+**	
RD-OTH42-P	CEO prevents R&D to do science for the sake of science	nm	**+**	This is the mirror statement of the statement made by several CEOs during the CEO interviews in that the focus of the R&D activities should be an science for business, not science for science
RD-OTH43-P	CEO is able to judge the value of his/her CSO	nm	**+**	The CEO should be sufficiently experienced in life science R&D firms that they are capable to distinguishing a powerful CSO from a mediocre one
RD-OTH44-P	CEO does not receive oversimplified messages as they can mislead him	nm	**+**	This statement was also made buy one CEO during the CEO interviews who argued that oversimplified message could lead to flawed decision making
RD-OTH45-P	CEO becomes nervous when science discussions take too long	nm	**+**	This is also corroborated by the CEO in this firm who stated that 'it starts to itch' when science meetings take too long
RD-OTH46-P	CEO interacts more with us to unload his perspective to us	nm	**+**	This R&D perspective points to the unidirectional relationship and the dominant attitude of the CEO vis-à-vis R&D

RD-OTH47-P	CEO teaches us about the business side of a LSRD firm	nm	**+**	The CEO should teach R&D about the business 'we are in'

nm: not mentioned

New themes emerging from interviews of RDE5P - RDE6P

> *'I think he also needs to be able to trust his CSO for example to a certain point so that there is a back and forward communication through his team'*
>
> *'It's also about trust'*

This concept of trust was linked to the R&D executives' argument that there is no need for a CEO to have detailed scientific knowledge as the science 'is our responsibility' and 'therefore there is a need for trust in our capabilities'. On the other hand **RDE6P** argues that trust needs to work in two directions, and R&D scientists also need to trust their CEO (an argument that was also made by the scientists in the first pilot interview of R&D executives):

> *'people really need to trust him'*

Another theme that was strongly emphasized by **RDE5P** is the concept of knowledge transformation when communicating R&D knowledge to the CEO ('CEO receives highly transformed R&D message that does not make any sense anymore to R&D' (RD-OTH30-P)).

> *'I think it qualifies as heavy transformation because the content is completely gone, the exact details on what you want to do and how you want to go about it is no longer present … we don't even discuss too much the details of what the output will be, it's simply a marketable asset. It has been completely transformed, it's almost metaphysical in the sense that we no longer talk about the subject, we talk about the overall aspect, the weight and the colour, this is a black 100 grams object....'.*

In addition, according to **RDE6P**, there is a risk that if the R&D message to the CEO is made too simple, it may be misleading for the CEO and his/her team. This comment was also made by CEO8 who argued that CEOs should not make decisions on (over-simplified R&D knowledge. The CEO should teach his R&D organization about the 'business side of things' in order for the R&D function to become an integral part in the strategy building of the firm, an argument which was also raised by the R&D executives in the first pilot firm. A number of knowledge related themes appeared such as 'CEO is not capable to judge the innovative character of an R&D proposal' (RD-OTH24-P), 'CEO does not have the scientific credentials to evaluate new proposals on its merits '(RD-OTH26-P) and 'CEO does not have detailed knowledge in the science' (RD-OTH29-P).

Again, other themes appeared that are considered granular and isolated from the majority of a priori themes. They are: 'CEO not only enables but also manages innovation' (RD-OTH22-P), 'CEO is involved in the operational aspects of innovation only' (RD-OTH23-P), 'CEO empowers the CSO to make decisions' (RD-OTH27-P), 'CEO is only suitable to think about budgets, timelines, deals' (RD-OTH28-P), 'CEO will more easily say 'no' to a project the more innovative it is' (RD-OTH31-P), 'CEO refuses R&D to take decisions' (RD-OTH32-P), 'CEO acts very intimidating and dominant towards the science community in the firm' (RD-OTH33-P), 'CEO takes a step back and tap into the brain

power of the organization' (RD-OTH34-P), 'CEO is very approachable' (RD-OTH35-P), 'CEO communicates the firm strategy to R&D' (RD-OTH36-P), 'CEO of a LSRD firm does not run the firm as a finance manager' (RD-OTH38-P) 'CEO involves R&D to develop a strategy and vision for the firm' (RD-OTH37-P); 'CEO understand the risks and challenges of life science R&D' (RD-OTH39-P), 'CEO is very isolated from R&D'(RD-OTH40-P), 'CEO has not time to talk to R&D' (RD-OTH41-P), 'CEO prevents R&D to do science for the sake of science' (RD-OTH42-P), 'CEO is able to judge the value of his/her CSO' (RD-OTH43-P), 'CEO does not receive oversimplified messages as they can mislead him' (RD-OTH44-P), 'CEO becomes nervous when science discussions take too long '(RD-OTH45-P), 'CEO interacts more with us to unload his perspective to us' (RD-OTH46-P) and 'CEO teaches us about the business side of a LSRD firm' (RD-OTH47-P).

Conclusion

This second pilot study shows that senior R&D scientists use still other role concepts to describe the role of the CEO in innovation in R&D. Because of the absence of a chief scientific officer in this firm it was possible to inquire about the role of the CEO with two senior R&D executives who were not accustomed to interact with the CEO and whose views can be considered 'fresh and unspoiled' from potential top management practices and politics. Although themes that emerged from the interviews are different from the themes that appeared from the interviews in the first pilot study, two themes re-emerged: the theme of 'trust' and the important role that it plays in the relationship with the CEO and the theme of 'learning' and 'knowledge transformation' when interacting with the CEO about their R&D projects.

Conclusion of the pilot interviews

First, concepts such as trust both *in* and *by* the CEO were articulated. It seems that 'trust' is a sensitive topic for R&D executives when discussing R&D and its relationship with the CEO. In both cases the concept of trust appeared without any stimulus from the part of the interviewer. Trust was referred to as a bi-directional concept: both the trust by the CEO in R&D as the trust by R&D in the CEO seemed to be important for R&D. In addition, the concept of trust was not referred to 'superficially', or as a 'passing theme' that emerged and disappeared among a myriad of other themes. On the contrary, it was articulated forcefully by the R&D scientists as if some sort of fundamental concept was addressed. What also re-emerged strongly during the interviews was the theme of R&D data complexity reduction. As one scientist argued – with visible irritation - : 'nothing is left over of my scientific proposal once it reaches the executive room- it's almost metaphysical in the sense that we no longer talk about the subject'. In addition, the theme of 'learning' and, related to that, the theme of 'knowledge', appeared frequently during the interviews and was bidirectional: the CEO teaches R&D about the market and business environment, while R&D teaches the CEO about the science. However, because the interview questions revealed a number of unexpected concepts in these pilot studies, it was decided to proceed with these questions into the final interviews. Because the theme of trust was clearly articulated it was tempting to modify our questionnaire to explore this theme further but it was decided not to do so and take the research forward using the questionnaire used for the pilot R&D studies above and –

assuming that the concept of trust plays an important role - it would emerge 'by itself' during the following 33 interviews.

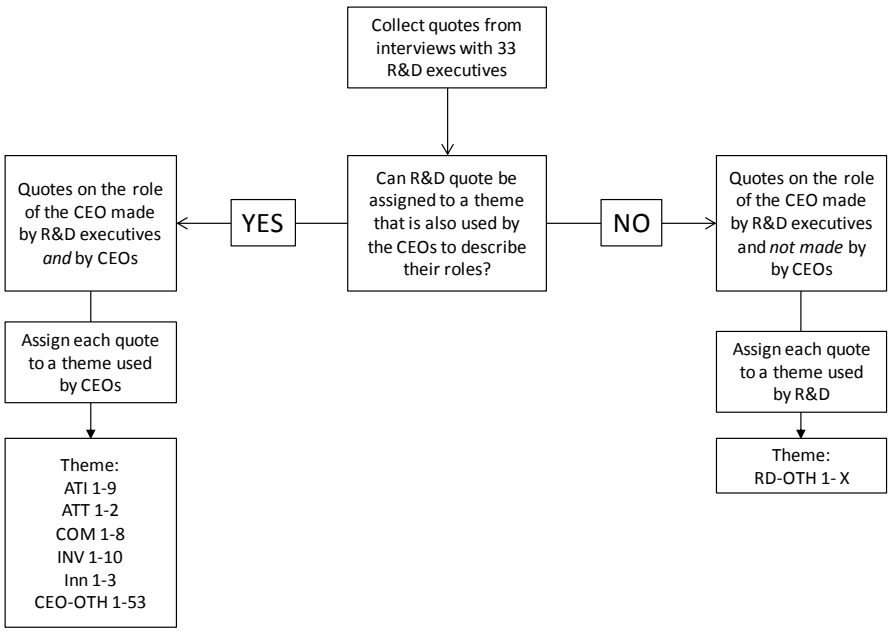
It also became clear during the interviews that R&D executives do not mind to be interviewed about their CEOs and the majority agreed to an interview without any restrictions. These R&D executives did not feel uncomfortable discussing top management leadership in R&D, they were however pleased to hear that:

- their CEO, nor anybody else in or outside the firm, will be informed about their individual visions about top management leadership
- the questions and the answers were destined for academic research purposes only and the interview was not part of a consultancy project introduced into the firm to improve their R&D effectiveness

In order to protect anonymity, it was decided to prepare a statement that would guarantee full confidentiality of the final interviews in addition to the confidentiality agreement that was agreed with the firm (through the CEO).

Final interview approach

For the analysis of the final R&D interviews, the approach presented below was used. The primary/secondary nodes structure which was developed after the interview of the CEO interviews was used for the content analysis of the interview transcripts of the R&D executives. The procedure followed for the final interviews followed the same approach as for the previous interviews: interview and recording, transcription of the recorded interview, correction of the transcript and analysis of the transcript were conducted in the same way as for the pilot CEO, the final CEO and the pilot R&D interviews. The diagram below presents the approach.



At the start of the R&D interview, each R&D executive was given a signed confidentiality statement. Each of the quotes is analyzed and either:

- assigned to a theme previously used by CEOs during their interviews and which they used to describe their role in innovation (i.e. to an a priori literature based theme ATI1--9, ATT1-2, COM1-8, INV1-10 or INN1-3 or to a CEO-based theme obtained from the CEO interviews CEO-OTH 1 to CEO-OTH53) or
- to a new theme that cannot be assigned to any of the themes above and is only used by R&D executives to describe the role of CEOs in innovation. If a quote reflects a theme that has not emerged during the interview with the CEOs, it is assigned a code 'RD-OTHx' indicating that it is a theme used by R&D executives ('RD'), that it is different from the literature concepts ('OTH' from 'other') and that it is the 'x'th theme identified in the R&D executives' interviews ('x')

The code 'RD-OTHx' is then identified as a new theme to which similar comments, quotes and remarks are assigned.

Appendix M. Overview of R&D executives

Firm	Function	R&D Executive: code*	CEO	Interview date	Interview mode	Rec. **
T	Chief Scientific Officer	RDE1 P	CEO1P	September 17, 2012	Face-to-face	Yes
	Senior Manager Search and Evaluation	RDE2 P		September 17, 2012	Face-to-face	Yes
	Head of Pharmacology, Oncology	RDE3 P		September 17, 2012	Face-to-face	Yes
	Senior manager Discovery Operations	RDE4 P		September 17, 2012	Face-to-face	Yes
A1	Principal Scientist Target Scouting	RDE5 P	CEO2	October 8, 2012	Face-to-face	Yes
	Senior Director Pharmacology	RDE6 P		October 8, 2012	Face-to-face	Yes
A2	Chief Scientific Officer	RDE7	CEO2P	November 8, 2012	Face-to-face	Yes
	Manager Science and Technology	RDE8		November 8, 2012	Face-to-face	Yes
C	Senior Manager Technology	RDE9	CEO1	December 11, 2012	Face-to-face	Yes
	Gent - GBR/PG	RDE10		December 11, 2012	Face-to-face	Yes
	Research Expert	RDE11		December 11, 2012	Face-to-face	Yes
B	Chief Scientific Officer	RDE12	CEO3	October 31, 2012	Face-to-face	Yes
	Director Assay, R&D	RDE13		October 19, 2012	Face-to-face	Yes
	Research Manager	RDE14		October 19, 2012	Face-to-face	Yes
	Director Life Sciences	RDE15		October 19, 2012	Face-to-face	Yes
T	Chief Scientific Officer	RDE16	CEO4	December 6, 2012	Face-to-face	Yes
A 3	Chief Scientific Officer	RDE17	CEO5	December 3, 2012	Face-to-face	Yes
	Vice president Chemistry	RDE18		December 3, 2012	Face-to-face	Yes
	Vice president Biology	RDE19		December 3, 2012	Face-to-face	Yes
	Vice president NCD	RDE20		December 3, 2012	Face-to-face	Yes
A4	Chief Scientific Officer	RDE21	CEO6	November 20, 2012	Face-to-face	Yes
	Research Fellow	RDE22		November 20, 2012	Face-to-face	Yes
C	Chief Scientific Officer	RDE23	CEO7	October 30, 2012	Face-to-face	Yes
R	Chief Scientific Officer	RDE24	CEO8	October 15, 2012	Face-to-face	Yes
	Senior Scientist	RDE25		October 15, 2012	Face-to-face	Yes
	Senior Scientist	RDE26		October 15, 2012	Face-to-face	Yes
S	Manager Science and Technology	RDE27	CEO9	November 5, 2012	Face-to-face	Yes
	Manager R&D	RDE28		November 5, 2012	Face-to-face	Yes
O	Chief Scientific Officer	RDE29	CEO10	December 10, 2012	Face-to-face	Yes
J	Global Head Drug Discovery J&J	RDE30	CEO11	November 21, 2012	Face-to-face	Yes
G	Chief Scientific Officer	RDE31	CEO12	January 24, 2013	Telephone	No
	President Grünenthal Innovation	RDE32		November 22, 2012	Telephone	Yes
	Sr vice president Marketing	RDE33		October 16, 2012	Face-to-face	Yes
	Sr vice president NCD	RDE34		October 16, 2012	Face-to-face	Yes
	Sr vice president Formulation	RDE35		October 16, 2012	Face-to-face	No

O	Chief Scientific Officer	RDE36	CEO13	December 7, 2012	Telephone	Yes
A5	Director Non Clinical Operations	RDE37	CEO14	December 20, 2012	Face-to-face	Yes
P	Director R&D Operations	RDE38	CEO15	December 17, 2012	Face-to-face	Yes
	Director R&D Technology	RDE39		December 17, 2012	Face-to-face	Yes

*****: each interviewed R&D executive was assigned a code for identification and classification purposes; ******: recording

Appendix N. Operational data of the R&D interviews

Interviewee R&D executive	Recording Nr.	Duration (in min)	Conversation type	Transcript* (nr of pages)	Nr of quotes extracted
RDE7	LS110137	48	face-to-face	10	13
RDE8	LS110136	43	face-to-face	10	15
RDE9	LS110163	32	face-to-face	9	12
RDE10	LS110161	27	face-to-face	7	5
RDE11	LS110162	27	face-to-face	7	10
RDE12	LS110132	56	face-to-face	12	30
RDE13	LS110131	29	face-to-face	7	18
RDE14	LS110129	29	face-to-face	8	14
RDE15	LS110130	29	face-to-face	7	14
RDE16	LS110158	36	face-to-face	10	23
RDE17	LS110157	33	face-to-face	9	27
RDE18	LS110154	43	face-to-face	10	15
RDE19	LS110155	35	face-to-face	9	17
RDE20	LS110156	24	face-to-face	7	19
RDE21	LS110138	43	face-to-face	11	20
RDE22	LS110139	17	face-to-face	6	7
RDE23	LS110149	57	face-to-face	16	18
RDE24	LS110124	48	face-to-face	12	27
RDE25	LS110126	21	face-to-face	6	15
RDE26	LS110125	23	face-to-face	5	17
RDE27	LS110133	45	face-to-face	11	16
RDE28	LS110134	31	face-to-face	9	13
RDE29	LS110160	31	face-to-face	9	16
RDE30	LS110140	34	face-to-face	8	15
RDE31	na	-	face-to-face	**	7
RDE32	LS110142	24	telephone	6	7
RDE33	LS110127	32	face-to-face	8	13
RDE34	LS110128	20	face-to-face	5	15
RDE35	na	-	telephone	***	5
RDE36	LS110159	20	telephone	5	14
RDE37	LS110166	25	face-to-face	6	15
RDE38	LS110165	22	face-to-face	7	16
RDE39	LS110164	25	face-to-face	8	6
		1100 min 18.3 hrs		260	494

*A4, Calibri, 11 font size, 1,15 line, space below section; **: interview not recorded as interviewee objected to recording; ***: interview not recorded due to instrument failure

Appendix O. Categorization of the R&D quotes

This appendix includes:

- Identification of the interviewed R&D executive (i.e. R&D Executive: RDE7 to RDE39
- a number assigned to each quote for each R&D executive (column 1). For example, during the interview with R&D executive RDE7 , 14 quotes were made each assigned a number 1 tot 14
- The actual quote made by the R&D executive (column 2)
- The argument (in the third column) why the quote in column 2, falls either in the category of
    - a theme previously used by CEOs (a priori theme or CEO-OTH theme; 4th column)
    - a new theme used by R&D executives and not by CEOs, i.e. RD-OTH1, RD-OTH2… RD-OTHn (5th column)

Overview and categorization of quotes observed during the interviews with the R&D executives				
Quotes made by R&D executives in chronological order as observed during the interview ↓		**Assignment of the quote to a theme that was either used by CEOs to describe their role in innovation or to a newly developed R&D based theme that was used by R&D executives to describe the role of their CEO in innovation ↓**	**PSNn CEO theme**	**New R&D theme**
Quotes made by R&D executive RDE7 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should be generous and show signs of selflessness	The argument that a CEO of a life science R&D firm should be altruistic, generous and have a noble purpose (see quote RDE7 3) cannot be assigned to any theme that emerged from a CEO interview. It is therefore assigned to a theme that is specific for R&D executives: RD-OTH1 CEO should focus on common good and act beyond personal ambition		**RD-OTH1**
2	CEO is rigid in control and drive	No CEO argued that he/she should have a strong controlling nature and show rigidity in his/her management of a LFSRD firm. However, it is argued by R&D executives that he/she should avoid discharging such a style: RD-OTH 2 CEO manages LSRD firms with rigidity and strict control		**RDOTH2**
3	CEO should have a noble purpose and not be limited to shareholder value	See above		**RDOTH1**
4	CEO should be willing to offer his/her time to R&D	This refers to CEO commitment and the willingness to 'devote time' to innovational efforts but – in line with our a priori definitions – is better defined as 'involvement' and is assigned to 'CEO holds frequent formalized meetings R&D"	**INV6**	
5	CEO should give time to people in R&D because he believes in them	CEO should trust R&D. A CEO who believes in 'his people' shows trust. The quote is therefore assigned to code CEO-OTH31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
6	CEO should act more qualitatively instead of quantitatively	This R&D executive argued that it is necessary for a CEO of a LSRD firm to use as well qualitative as quantitative thinking. He/she means that the CEO should understand not only the (financial) figures but		**RD-OTH3**

		also the 'soft side' of managing and leading scientists and scientific R&D: RD-OTH3 CEO manages qualitatively and quantitatively		
7	CEO should learn more about human relations in order to be able to work with R&D	See above		**RD-OTH3**
8	CEO should have a lot of inside energy	RD-OTH4 CEO should be forceful and full of drive		**RD-OTH4**
9	CEO should have a relationship with R&D scientists built on trust	CEO should trust R&D. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO trusts R&D'	**CEO-OTH31**	
10	CEO of a LFSRD firm should not act as dominantly	This was also raised by a CEO during his/her interview. This refers to the CEO quote that CEOs in a life science R&D organization should not act as 'dominant' figures	**CEO-OTH39**	
11	CEO should have deep insight in the mechanisms that rune the world	No interviewed CEO argued that he/she should have a philosophical insight into 'reality'. This CSO feels that CEOs should be more than only managers, they should have a strong literature background and knowledge of philosophy. RD-OTH5 CEO has a strong cultural and literature background		**RD-OTH5**
12	CEO should not become involved in the details irrespective of his background	No CEO who was interviewed argued that he/she should (not) meddle with the scientific activities of the R&D scientists. However, R&D executives who appreciate CEO involvement do not appreciate CEOs who 'meddle' with the science, either in the lab or in specialized in-depth scientific dialogue. RD-OTH6 CEO should not interfere with the science		**RD-OTH6**
13	CEO trusted me to do things	CEO should trust R&D. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence '	**CEO-OTH31**	
14	CEO should not meddle with the science	see above		**RD-OTH6**
Quotes made by R&D executive RDE8 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO role is primarily strategic	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
2	CEO role in innovation is to focus	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
3	CEO should balance R vs. D and balance academic vs. industrial R&D	No CEO argued that it is necessary to 'balance' industrial vs. academic research; on the contrary, industrial research was the CEO's primary objective. This R&D executive requires a balance between both research streams. RD-OTH 7CEO should balance industrial vs. academic work		**RD-OTH7**
4	CEO should not only rely on academic advice	This R&D executive argued that it is dangerous for a CEO to fully rely on the advice of an academic (the firm is an academic spin-off). This reliance may be useful but is only part of the full and balanced picture that a CEO requires about the potential of a scientific/ commercial opportunity. RD-OTH8 CEO requires a balanced view of the potential of R&D		**RD-OTH8**
5	CEO needs a scientific advisor independent from academia	Same as above		**RD-OTH8**
6	CEO should be careful with scientists who fall in love with their technology	The CEOs argued that they should not focus on the technology because it detracts from the focus of the R&D activities	**CEO-OTH4**	
7	CEO should not be dislocated from the site where R&D is conducted	The CEO should never be dislocated from the main research center as this prohibits the potential interaction between CEO and R&D. RD-OTH10 CEO should be located in proximity of the R&D site.		**RD-OTH10**
8	CEO needs to have the final word in biotech R&D	The CEO, not the management team or the CSO should have the final word in R&D decisions. RD-OTH10 CEO makes final R&D decision		**RD-OTH11**
9	CEO should be a good listener	Not only should the CEO be a good communicator, according to R&D he should also be a good listener. RD-OTH12 CEO is a good listener		**RD-OTH12**

10	CEO should be able to talk the language of the different departments in the firm	Not only should the CEO be a good communicator (according to the CEO), he should also be a good listener (according to R&D) but he should also be capable to use the different languages especially the language and jargon of scientists. RD-OTH13 CEO is capable to talk the language of scientists		**RD-OTH13**
11	CEO does not need to know the ins and outs of science	The 'ins and outs' of science refer to the detailed level of knowledge required by R&D scientists to conduct research. The level of knowledge is not needed for a CEO. It implies that – although the 'ins and outs' are not required, CEOs should have some understanding of the science in which their firms are engaged	**CEO-OTH38**	
12	CEO should be sufficiently well trained in science to be able to cope with the pressure from an academic CSO	See above		**RD-OTH8**
13	CEO is capable to see the value of science and how to achieve its potential	According to R&D, CEOs should be capable of evaluating a scientific project or innovational idea. This is linked to the observations of absorptive capacity that emerged from the CEO interviews and is now supported by R&D. If CEOs should be capable to evaluate new knowledge (before eventual firm assimilation and exploitation takes place) he/she should be able to understand it. Knowledge that is available in R&D should be 'absorbable' by a CEO. RD-OTH9 CEO should be capable to evaluate R&D knowledge		**RD-OTH9**
14	CEO should receive R&D knowledge that is reduced to a level that he/she can challenge it	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
15	CEO should be careful in running a company that is 'run' by a strong academically oriented CSO	See above		**RD-OTH8**
Quotes made by R&D executive RDE9 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should have devoted budget	This refers to a CEO commitment – the willingness to make available human and financial resources to a project. CEO makes available human and financial resources	**COM4**	
2	CEO should create culture of innovation	CEO fosters a culture of innovation	**ATI1**	
3	CEO recognizes the need for innovation	A CEO who recognizes the need for innovation has the 'correct attitude' to allow innovation to proceed. Although this quote is of a general nature, it is decided to assign this quote to theme ATT1.	**ATI1**	
4	CEO double-checks the information received from R&D	This quote refers to the statement made by the R&D executive who argues that if the CEO would start double-checking the opinions and/or data, this would be considered a lack of trust. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
5	CEO is offered R&D knowledge without details and which is self-explanatory	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
6	CEO attempts to understand the science in R&D	See above	**CEO-OTH10**	
7	CEO should have prior knowledge so that R&D can convince him/her about budget needs	See above	**CEO-OTH5**	
8	CEO should receive the correct know-how from R&D	This quote is made by a R&D executive who argues that if he/she is responsible for offering R&D know how to the CEO, that this know-how should be such that the CEO receives correct information thereby building the foundation for a relationship built on trust. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
9	CEO should not only 'manage people'	This quote is made by R&D executives who argue that R&D scientists should not be 'managed' but led. RD-OTH13 CEO should *lead* scientists, not *manage* them		**RD-OTH14**

10	CEO should understand the science within R&D	The CEO should have an understanding and have sufficient knowledge of the science that is being used in the LSRD firm. RD-OTH15 CEO should have sufficient knowledge of science to be effective		**RD-OTH15**
11	CEO talk to everybody in R&D	CEO gets information from/discusses R&D with all levels	**CEO-OTH20**	
12	CEO should receive considerably simplified R&D know-how	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
Quotes made by R&D executive RDE10 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO pulls all science resources together to achieve a goal	Although this quote refers to 'resources', it indicates that the CEO pulls 'everybody and everything' together to achieve a goal. In this sense, the quote refers to 'setting a direction/goal' (more than to pull 'human and financial resources' together) and even more to 'focus' and the setting of boundaries, which is only done when a project is well defined. Therefore, the quote is assigned to ATT2.	**ATT2**	
2	CEO sets the right direction	CEO sets the direction/goal and vision in which innovation to take place. CEO sets the direction/goal and vision in which innovation to take place	**ATT1**	
3	CEO should make sure no R&D unit works in silo	This refers to a CEO commitment – the creation of appropriate organizational structures for an innovation project to be successful	**COM6**	
4	CEO should involve people from the floor in innovation	CEOs should involve people from the R&D floor as they have a lot of know-how and sometimes have great innovative ideas RD-OTH16 CEO should involve all levels of R&D		**RD-OTH16**
5	CEO is not expected to offer new topics for innovation	According to R&D it is not the CEO who proposes topics for innovation. In this case, innovational ideation is limited to the scientists. RD-OTH17 CEO is not expected to come up with new ideas		**RD-OTH17**
Quotes made by R&D executive RDE11 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO offers freedom to R&D	Obtaining freedom to operate in an R&D environment requires the CEO to have trust in the R&D function and is part of a relationship of trust between CEO and R&D. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
2	CEO offers his confidence and trusts me	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
3	CEO receives oversimplified R&D messages and based on timelines and budget	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
4	CEO may take the wrong decision when receiving the simplified message	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
5	CEO offers an environment for open discussion	CEO fosters a culture of innovation	**ATI1**	
6	CEO should have knowledge on the science of R&D	CEO stresses the importance of strong knowledge in the field of innovation	**CEO-OTH5**	
7	CEO who drives a LSRD firm based on financial is catastrophic	R&D executives argue that a CEO who is driven by financial figures when it comes to R&D may be detrimental for R&D in the firm. RD-OTH 18 CEO should drive R&D not only from a financial point of view		**RD-OTH 18**
8	CEO sets the right long term strategy	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
9	CEO is a fast learner and has a scientific background	Although CEOs argued that they foster communication and learning in the organization, their arguments focuses on the learning of the organization itself and not necessarily on the learning of the CEOs by the R&D function. According to R&D CEOs can be divided in fast learners and slow learners.		**RD-OTH15**
10	CEO is a slow learner and has no biotech R&D knowledge	See above		**RD-OTH15**
Quotes made by R&D executive RDE12 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				

1	CEO brings a lot of industrial experience in the company	During the CEO interviews no CEO argued that part of his management of a life science R&D resides in their experience accumulated during the previous years. According to R&D executives the level of experience of a CEO is important to better understand the risk associated with R&D.RD-OTH19 CEO contributes to R&D by means of his/her experience		**RD-OTH19**
2	CEO should make the company survive	CEO makes available human and financial resources	**COM4**	
3	CEO should continue to do innovation	CEO fosters a culture of innovation	**ATI1**	
4	CEO needs direction and focus and look for opportunities	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT**	
5	CEO should not be a life-scientist	Although CEOs referred to their knowledge in science as part of the discussion on their involvement, according to R&D executives there is no strict requirement as to the prior knowledge of CEOs. That a CEO is a life scientist is neither an advantage nor a disadvantage. According to R&D executives, CEO attitude is much more important than prior knowledge. The fact that R&D can learn from their CEOs that is complementary to their own knowledge is considered worthwhile. Alternatively, R&D can teach the CEO what he/she does not know or understand. R&D executives however find it easier to have a CEO with a science background because it makes the explaining of the science to the CEO easier. RD-OTH19 CEO do not need scientific knowledge (but when it is available it may help).		**RD-OTH20**
6	CEO should create the right environment	CEO fosters a culture of innovation	**ATI1**	
7	CEO should help us focus	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
8	CEO focus that is where he is really strong – I think he is really focused	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
9	CEO should be involved at all levels	CEO gets information from/discusses R&D with all levels	**CEO-OTH20**	
10	CEO keeps the focus	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
11	CEO builds structures and the organization	This refers to a CEO commitment – the creation of appropriate organizational structures for an innovation project to be successful	**COM6**	
12	CEO builds innovation teams in order not to detract from market orientation	This refers to a CEO commitment – the creation of appropriate organizational structures for an innovation project to be successful	**COM6**	
13	CEO builds a culture of innovation	CEO fosters a culture of innovation	**ATI1**	
14	CEO networks helps R&D to innovate	CEO fosters external collaboration to increase internal innovation	**ATI5**	
15	CEO tries to stimulate people to innovate	CEO fosters a culture of innovation	**ATI1**	
16	CEO thinks along with us to create innovation	CEO comes up with new innovative ideas	**INV8**	
17	CEO trust and belief in the team is important	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
18	CEO learns from R&D and joins in scientific meetings	During the CEO interviews the CEOs referred to the learning of the organization but not their own learning neither to the learning of R&D. Both R&D and CEO learn from each other. RD-OTH21 CEO learns from R&D and R&D learns from CEO		**RD-OTH21**
19	CEO receives R&D knowledge reduced to the medical need in the market to allow portfolio discussions	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
20	CEO teaches R&D about the market	See above		**RD-OTH21**
21	CEO does not need a scientific background	CEO considers it an advantage to be untrained in science	**CEO-OTH12**	

22	CEO learns about innovations made by R&D so that he can take decisions	See above		**RD-OTH21**
23	CEO contributes to innovation using his expertise only	CEO comes up with new innovative ideas	**INV8**	
24	CEO challenges R&D with a market focus	CEO challenges R&D technically	**INV2***	
25	CEO may be dominating the meetings	This refers to the CEO quote that CEOs in a life science R&D organization should not act as 'dominant' figures	**CEO-OTH39**	
26	CEO receives know how from R&D that is reduced in complexity	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
27	CEO helps to maintain the right innovation environment	CEO fosters a culture of innovation	**ATI1**	
28	CEO uses 'corridor talks' to become informed about innovation	CEO gets information from/discusses R&D with all levels	**CEO-OTH20**	
29	CEO requires experience in the field to be effective in innovation and not necessarily relevant education or knowledge	See above		**RD-OTH19**
30	CEO grows from within the firm to become effective in leading research	See above		**RD-OTH19**
Quotes made by R&D executive RDE13 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should make sure there is an environment for innovation	CEO fosters a culture of innovation	**ATI1**	
2	CEO should have a long term view	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
3	CEO should have focus	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
4	CEO balances short – and long term innovation vs day-to-day management of R&D	According to R&D executives long term innovation and short term innovation should be balanced in order not to jeopardize the long term survival of the firm. RD-OTH CEO balances short-term vs. long term innovation		**RD-OTH22**
5	CEO learns science from R&D	See above		**RD-OTH21**
6	CEO should not be an expert in science	CEOs should have some understanding of the science in which their firms are engaged	**CEO-OTH38**	
7	CEO talks at all levels in R&D	CEO gets information from/discusses R&D with all levels	**CEO-OTH20**	
8	CEO should walk around in R&D in order to avoid a limited, poor, reduced version of R&D	CEO gets information from/discusses R&D with all levels	**CEO-OTH20**	
9	CEO is capable to use science to make money	CEO top scientist/top business man/women is ideal	**CEO-OTH41**	
10	CEO is an extremely smart person and absorbs knowledge fast	See above		**RD-OTH9**
11	CEO is eager to learn from the scientists	See above		**RD-OTH21**
12	CEO wants to learn from R&D because of lack in knowledge but interest in R&D	CEO attempts to understand R&D expertise	**CEO-OTH10**	
13	CEO only wants to discuss budget and timelines	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
14	CEO teaches R&D about the market and makes sense of my R&D	See above		**RD-OTH21**
15	CEO learns from R&D and R&D learns from the CEO	See above		**RD-OTH21**
16	CEO should have a long term visions	CEO sets the direction/goal and vision in which innovation to take place.	**ATT1**	

17	CEO should have some science background but more importantly a strong business background	See above		**RD-OTH20**
18	CEO experience is more important than scientific expertise	See above		**RD-OTH19**
Quotes made by R&D executive RDE14 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should pick up opportunities	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
2	CEO communicates these opportunities	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
3	CEO has sufficient budget	CEO makes available human and financial resources	**COM4**	
4	CEO should have a good business view on opportunities	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
5	CEO should be supportive for innovation	CEO fosters a culture of innovation	**ATI1**	
6	CEO should leave research alone	Obtaining freedom to operate in an R&D environment requires the CEO to have trust in the R&D function and is part of a relationship of trust between CEO and R&D. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
7	CEO should focus	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
8	CEO should allow researcher to act freely	Obtaining freedom to operate in an R&D environment requires the CEO to have trust in the R&D function and is part of a relationship of trust between CEO and R&D. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
9	CEO is involved from the business opportunity side	CEO evaluates economic viability of R&D project	**INV9**	
10	CEO receives data that are reduced in complexity in order for the CEO to graps the message	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
11	CEO receives message which are reduced in complexity and helps R&D to think about the real issues	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
12	CEO trust me	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
13	CEO can be a non-scientist and that is not a disadvantage	See above		**RD-OTH20**
14	CEO trust is always important	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
Quotes made by R&D executive RDE15 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should recognize the value of the technology	See above		**RD-OTH9**
2	CEO should be able to exploit our technologies	CEO evaluates economic viability of R&D project		**RD-OTH9**
3	CEO should scan the environment for opportunities	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	

4	CEO should be a master in communication	CEOs do not reflect on their ability as communicator, but R&D executives stressed the fact that CEO should be particularly well good communicators especially in view of articulating their vision for the firm: RD-OTH 23CEO is a good communicator		**RD-OTH23**
5	CEO should give the direction towards a common goal	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm and	**ATT1**	
6	CEO should have corridor meetings to avoid agendas	By 'corridor' meetings was meant the action taken by CEOs to walk through the labs and talk about the scientific problems and projects whereby he/she obtains information from/discusses R&D with all levels	**CEO-OTH20**	
7	CEO teaches R&D and R&D teaches CEO	See above		**RD-OTH21**
8	CEO learns from R&D in corridor meetings	See above		**RD-OTH21**
9	CEO receives RD messages for the CEO to understand	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
10	CEO receives simplified messages	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
11	CEO already has some background knowledge that helps the message to be constructed	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
12	CEO is teached by R&D for him to understand the message	See above		**RD-OTH21**
13	CEO teaches us about the market	See above		**RD-OTH21**
14	CEO should trust us	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
Quotes made by R&D executive RDE16 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO sets the direction	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
2	CEO makes use the interactions are conducive to innovation	CEO fosters a culture of innovation	**ATI1**	
3	CEO is involved in the teams to steer the teams	CEO is involved in NPD	**INV5**	
4	CEO needs a basic understanding of the development of new products in life science	RD-OTH 24 CEO understand the new product development process and its risks		**RD-OTH24**
5	CEO dares to take decisions	R&D executives want their CEOs not only to be smart and have a lot of experience, they also want their CEOs to be courageous in taking bold ideas into an innovative environment RD-OTH25 should be willing to take risks in innovation		**RD-OTH25**
6	CEO should set another direction if needed	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
7	CEO needs some basic knowledge about the science	See above	**CEO-OTH5**	
8	CEO should respect R&D and R&D should respect the CEO	Respect in this case is also interpreted as trust; each party should trust each other and therefore respects each other experiences, arguments , expertise and conclusions	**CEO-OTH9**	
9	CEO is a challenger	CEO challenges R&D technically	**INV2**	
10	CEO is a catalyst	CEO fosters a culture of innovation	**ATI1**	
11	CEO as a scientist has some advantage	See above		**RD-OTH20**
12	CEO who is not a scientist can act as outside 'quality control' of R&D	This argument was used by one CEO who stated that is much more useful to be a non-scientists so that I can ask the right questions	**CEO-OTH12**	
13	CEO should not interfere	See above		**RD-OTH6**

14	CEO brings valuable ideas from his network	CEO fosters external collaboration to increase internal innovation	**ATI5**	
15	CEO should not tell us what to do with new ideas and proposals	See above		**RD-OTH6**
16	CEO learns from R&D	See above		**RD-OTH21**
17	CEO receives R&D know how that is reduced in complexity	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
18	CEO receives presentations from R&D that are market context driven	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
19	CEO as a scientist has an advantage but also carries a risk to become too much involved in the science	See above		**RD-OTH6**
20	CEO should trust his R&D people	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
21	CEO should be trusted by R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
22	CEO should know where the company goes	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
23	CEO should trust his R&D people	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
Quotes made by R&D executive RDE17 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should define the strategy and direction	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
2	CEO should make sure all legal aspects of R&D are covered	Surprisingly, R&D executives want their CEOs to make sure that all legal aspects of the development of new products are fulfilled.RD-OTH CEO makes sure that innovation is conducted in compliance with regulations		**RD-OTH25**
3	CEO with a scientific background can play a role in creating new opportunities	See above		**RD-OTH15**
4	CEO without science knowledge needs a science manager to run the science	See above		**RD-OTH20**
5	CEO uses his /her network to engage R&D	CEO fosters external collaboration to increase internal innovation	**ATI5**	
6	CEO as a scientist is risky as they can get too involved in science	See above		**RD-OTH6**
7	CEO as a scientists should let go off the science	See above		**RD-OTH6**
8	CEO should be familiar with drug development processes and risks	See above		**RD-OTH24**
9	CEO should network to discover opportunities	CEO fosters external collaboration to increase internal innovation	**ATI5**	
10	CEO who is as knowledgeable as the CSO should take a step back	See above		**RD-OTH6**
11	CEO who interferes with the scientist's work will not be able to keep their scientists	See above		**RD-OTH6**
12	CEO should leave the science to the scientists at one point during the company's growth	See above		**RD-OTH6**

13	CEO as a good scientists are not good CEOs because they meddle too much	See above		**RD-OTH6**
14	CEO innovates by challenging processes in R&D	CEO challenges R&D for efficiency	**INV1**	
15	CEO has a good understanding of the science		**CEO-OTH5**	
16	CEO with science based background will be better placed to assess the risks of a R&D project	See above		**RD-OTH15**
17	CEO without a science background need to be controlled by a CSO in order for the CEO to make the correct scientific decisions	See above		**RD-OTH15**
18	CEO should guarantee a stable environment for R&D to conduct its work	R&D executives argue that a CEO should be able to make sure that the environment to innovate is stable, i.e. that they van focus on their objectives without frequent changes in focus	**ATT2**	
19	CEO messages from R&D need to be simplified	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
20	CEO is open and honest	CEO fosters a culture of innovation	**ATI1**	
21	CEO challenges R&D	CEO challenges R&D for efficiency	**INV1**	
22	CEO should trust his CSO and R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
23	CEO looks for opportunities himself	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
24	CEO without science knowledge or experience will have a difficult time to understand R&D and its underlying processes	See above		**RD-OTH15**
25	CEO biggest problem of the experience of the development aspect of R&D	See above		**RD-OTH19**
26	CEO is bright but it all comes down to experience in development	See above		**RD-OTH19**
27	CEO without experience will overreact to R&D issues	See above		**RD-OTH19**
Quotes made by R&D executive RDE18 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should have a vision	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
2	CEO should have scientific focus and drive	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
3	CEO should balance internal and external resources	CEO fosters external collaboration to foster internal innovation	**ATI5**	
4	CEO needs to build trust in the company	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
5	CEO should build structures for innovation	CEO makes available human and financial resources	**COM4**	
6	CEO should instill integrity in the company	See above		**RD-OTH1**
7	CEO acts as a challenger of science	CEO challenges R&D for efficiency	**INV1**	
8	CEO learns from R&D	See above		**RD-OTH21**
9	CEO understands the basics of R&D	CEOs should have some understanding of the science in which their firms are engaged	**CEO-OTH38**	

10	CEO receives 'balanced' information from R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
11	CEO has sufficient knowledge that prevents the message to be simplified	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
12	CEO should have a clear vision	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
13	CEO receives oversimplified messages that can lead to the wrong decisions	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
14	CEO as a strong businessman and strong scientists is the ideal	CEO top scientist/top business man/women is ideal	**CEO-OTH41**	
15	CEO should have a vision	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
16	CEO looks for new ideas him/herself	CEO comes up with new innovative ideas	**INV8**	
Quotes made by R&D executive RDE19 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO needs to make sure money flows into the company	CEO makes available human and financial resources	**COM4**	
2	CEO needs to trust his scientists	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
3	CEO needs to think strategically and build a strategy	The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
4	CEO should trust their scientists	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
5	CEO with science background is too much inward looking while a business CEO is outward looking	See above		**RD-OTH6**
6	CEO builds a scientific network for us to profit from	CEO fosters external collaboration to increase internal innovation	**ATI5**	
7	CEO builds scientific network that may help build trust with his/her R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
8	CEO who double checks has a trust problem	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
9	CEO needs experience in R&D environments and their markets	See above		**RD-OTH19**
10	CEO understand the process of new product development and the risks involved	CEO needs to understand process/risks of R&D	**CEO-OTH34**	
11	CEO with science knowledge is an advantage for R&D	See above		**RD-OTH15**
12	CEO with no science background can do a great job	See above		**RD-OTH20**
13	CEO learns from R&D	See above		**RD-OTH21**
14	CEO builds a strategic vision	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
15	CEO build network that are important fro R&D	CEO fosters external collaboration to increase internal innovation	**ATI5**	
16	CEO should offer us his trust	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	

17	CEO prior knowledge leads to faster decision making	See above		**RD-OTH15**
Quotes made by R&D executive RDE20 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should represent R&D to the outside world	**RD-OTH 25 CEOs should be able to represent the science of their firms**		**RD-OTH26**
2	CEO should be able to talk about R&D to the outside world at a professional level	See above		**RD-OTH26**
3	CEO should set the vision for the future	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
4	CEO needs to be pulled down to reality by means of scientific arguments	R&D executives argue that in some cases CEOs 'oversell' their science. RD-OTH26 CEOs should be brought back to scientific reality		**RD-OTH27**
5	CEO needs to have an open mind and empower people	CEO fosters a culture of innovation	**ATT1**	
6	CEO needs to have a clear vision	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
7	CEO should make sure there are resources available	CEO makes available human and financial resources	**COM4**	
8	CEO should not push back new innovative ideas	R&D executives argue that some CEOs are afraid of innovative ideas RD-OTH27 CEOs should embrace new innovative ideas		**RD-OTH28**
9	CEO looks ahead? Then R&D will also look ahead!	CEO acts as a role model for innovation	**CEO-OTH17**	
10	CEO should share and articulate his vision with R&D	CEO fosters internal communication	**ATI3**	
11	CEO does not make sufficient time available for R&D	CEO has no time to talk to R&D	**CEO-OTH50**	
12	CEO does not trust me if he mingles with R&D	If the CEO would start to mingle with the scientists this behavior would be considered a sign of distrust by this R&D executive. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
13	CEO receives simplified R&D messages not because he could not understand otherwise but because he would become confused	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
14	CEO is knowledgeable about the development process	CEO needs to understand process/risks of R&D	**CEO-OTH34**	
15	CEO should make sure there are resources and money	CEO makes available human and financial resources	**COM4**	
16	CEO as a strong businessman and strong scientists is the ideal	CEO top scientist/top business man/women is ideal	**CEO-OTH41**	
17	CEO acting as a CSO cannot be successful because he is too much involved in the science	See above		**RD-OTH6**
18	CEO needs to trust his people	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
19	CEO challenges the process continuously	CEO challenges R&D for efficiency	**INV1**	
Quotes made by R&D executive RDE21 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO offers the opportunity to explore the novel principles that makes sense to the business	If the CEO allows the R&D function to explore opportunities of novel principles this is indicative of a sign of trust. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
2	CEO has strong scientific background	See above		**RD-OTH15**

3	CEO needs to trust R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
4	CEO without background in the R&D cannot decide	See above		**RD-OTH15**
5	CEO can only point into a certain direction because he understand the science	See above		**RD-OTH15**
6	CEO translates the science into a selling proposition	If a CEO is capable to translate the science in a selling proposition , it means that he was able to evaluate the scientific proposition. It is part of his absorptive capacity.		**RD-OTH9**
7	CEO is really and honestly interested in science	See above		**RD-OTH21**
8	CEO should be visible to R&D	CEO fosters internal communication	**ATI3**	
9	CEO is transparent and communicative	CEO fosters a culture of innovation	**ATI1**	
10	CEO discusses science ad hoc	CEO acts as a sounding board	**INV3**	
11	CEO trusts me and therefore a knowledge gap exists	If there is a knowledge gap and the CEO does not wants to become informed about the science, he/she can do so because he/she fully trusts me. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
12	CEO builds networks that are useful for R&D	CEO fosters external collaboration to increase internal innovation	**ATI5**	
13	CEO sets the direction	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
14	CEO learns R&D about the business and the market through its networks	CEO fosters external collaboration to increase internal innovation	**ATI5**	
15	CEO has a good background in science	See above		**RD-OTH15**
16	CEO is a good communicator	See above		**RD-OTH26**
17	CEO requires a minimum of science knowledge	See above		**RD-OTH15**
18	CEO should not be dominant	This refers to the CEO quote that CEOs in a life science R&D organization should not act as 'dominant' figures	**CEO-OTH39**	
19	CEO receives simplified messages from R&D	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
20	CEO should conduct the complexity reduction of the science, not R&D	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
Quotes made by R&D executive RDE22 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO opens the door to innovation	CEO fosters a culture of innovation	**ATI1**	
2	CEO builds networks from which R&D learns	CEO fosters external collaboration to increase internal innovation	**ATI5**	
3	CEO knows where to go with firm	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
4	CEO has a good knowledge of science	CEOs should have some understanding of the science in which their firms are engaged	**CEO-OTH38**	
5	CEO received R&D data that are simplified in order to create the necessary perception with him/her	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
6	CEO should trust R&D	CEO-OTH31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
7	CEO makes efforts to understand the background of science	CEO attempts to understand R&D expertise	**CEO-OTH10**	
Quotes made by R&D executive RDE23 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should make innovation possible	CEO fosters a culture of innovation	**ATI1**	

2	CEO should not become too much involved			**RD-OTH6**
3	CEO should not be dominant	This refers to the CEO quote that CEOs in a life science R&D organization should not act as 'dominant' figures	**CEO-OTH39**	
4	CEO should create an environment that is conduce to innovation	CEO fosters a culture of innovation	**ATI1**	
5	CEO should hire the right people	CEO hires selects and develops innovative leadership	**COM1**	
6	CEO should not be dominant	This refers to the CEO quote that CEOs in a life science R&D organization should not act as 'dominant' figures	**CEO-OTH39**	
7	CEO has to create the environment to allow innovation	CEO fosters a culture of innovation	**ATI1**	
8	CEO should show the direction to innovate	CEO sets the direction/goal and vision in which innovation to take place.	**ATT1**	
9	CEO should create the right conditions for innovation: hire the right people	CEO makes available human and financial resources	**COM4**	
10	CEO should give the right direction to R&D people	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
11	CEO should shows the direction in which R&D should move	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
12	CEO should allow communication, listen to suggestions, comments, positive or negative	CEO fosters a culture of innovation	**ATI1**	
13	CEO needs to find the right *means the right people*, create the atmosphere, the possibilities	CEO makes available human and financial resources	**COM4**	
14	CEO needs to find the right means the right people, *create the atmosphere*, the possibilities	CEO fosters a culture of innovation	**ATI1**	
15	CEO builds networks R&D can profit from	CEO fosters external collaboration to increase internal innovation	**ATI5**	
16	CEO challenges R&D	CEO challenges R&D technically	**INV2**	
17	CEO without science background is more difficult to convince	See above		**RD-OTH15**
18	CEO message is being simplified	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
Quotes made by R&D executive RDE24 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO trust in R&D supports innovation	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
2	CEO challenges and criticizes R&D	CEO challenges R&D technically	**INV2**	
3	CEO is trusted by R&D so that challenging can take place	CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
4	CEO builds a network	CEO fosters external collaboration to increase internal innovation	**ATI5**	
5	CEO has perspectives that may contribute to R&D	See above		**RD-OTH19**
6	CEO creates an atmosphere of trust that we are working for the whole	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
7	CEO accepts arguments and will not misinterpret them and used against you	The R&D executive argues that it is important that the communi-cation of sensitive data to the CEO will not 'fire back' when it is made public and in 'the open'. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	

8	CEO should trust our expertise : that is a basic	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
9	CEO trusts our data as he is using them in his network	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
10	CEO should trusts R&D because the data are not in his field of expertise	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
11	CEO is involved in matters that are linked to his expertise	CEO-OTH3	**CEO-OTH3**	
12	CEO contributes to innovation because he challenges	CEO challenges R&D for efficiency	**INV1**	
13	CEO has no knowledge gap but has knowledge that complements the R&D knowledge	CEO and CSO are innovative forces together	**CEO-OTH25**	
14	CEO background is not very important, attitude is more important	CEO fosters a culture of innovation	**ATI1**	
15	CEO will be teached by R&D if he/she shows a lack in knowledge	See above		**RD-OTH21**
16	CEO does not need to have deep R&D knowledge to challenge the data	CEOs should have some understanding of the science in which their firms are engaged	**CEO-OTH38**	
17	CEO messages are simplified to make them 'absorbable'	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
18	CEO should have no prior detailed knowledge but should have analytical capabilities	See above		**RD-OTH20**
19	CEO argues that we are not in for academic work	CEO wants R&D to step out of academic thinking	**CEO-OTH7**	
20	CEO should trust us that we ourselves with increase the output of R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
21	CEO trust is more important than a bonus	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
22	CEO should promote open communication	CEO fosters internal communication	**ATI3**	
23	CEO argues about the direction R&D needs to take	CEO sets the direction/goal and vision in which innovation to take place.	**ATT1**	
24	CEO has a strong vision	CEO sets the direction/goal and vision in which innovation to take place.	**ATT1**	
25	CEO should be very much motivating and supporting the R&D people to get the best of them	CEO fosters a culture of innovation	**ATI1**	
26	CEO should be very involved and interested in our work	CEO is involved in NPD	**INV5**	
27	CEO knowledge is not that important, its attitude	See above		**RD-OTH20**
Quotes made by R&D executive RDE25 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO builds networks for R&D	CEO fosters external collaboration to increase internal innovation	**ATI5**	
2	CEO allows R&D to learn through the network	CEO fosters external collaboration to increase internal innovation	**ATI5**	
3	CEO sees the science in a broader context and learns R&D to see through that broader context (ie business)	See above		**RD-OTH21**
4	CEO does not necessarily need to be a scientist	See above		**RD-OTH20**
5	CEO offers the resources to R&D	CEO makes available human and financial resources	**COM4**	
6	CEO should be critical and should 'juggle' with our data	CEO challenges R&D technically	**INV2**	
7	CEO should offer the R&D trust and confidence for operational freedom	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
8	CEO is open to (operational) freedom and is open minded	CEO fosters a culture of innovation	**ATI1**	

9	CEO looks at the R&D data from his own perspective	CEO interacts with R&D only in those matters he/she has personal knowledge in	**CEO-OTH3**	
10	CEO teaches R&D about the market	See above		**RD-OTH21**
11	CEO allows R&D to learn from his/her network	CEO fosters external collaboration to increase internal innovation	**ATI5**	
12	CEO trusts his R&D team leader	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
13	CEO can be trusted by R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
14	CEO trust leads to more innovation	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
15	CEO trust leads to more innovation because R&D can show its ideas without restriction	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
Quotes made by R&D executive RDE26 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO has to play a positive role in innovation and to create the atmosphere to innovate	CEO fosters a culture of innovation	**ATI1**	
2	CEO should trust his CSO and R&D and it's the most important thing	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
3	CEO is being trusted by R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
4	CEO teaches R&D about his expertise	See above		**RD-OTH21**
5	CEO has weekly meetings with R&D	CEO holds frequent formalized meetings with R&D	**INV6**	
6	CEO should give us his trust	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
7	CEO should give the people the opportunity to learn	CEO fosters learning in the organization	**ATI7**	
8	CEO teaches R&D about his expertise outside of science	See above		**RD-OTH21**
9	CEO needs to give the direction to R&D	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
10	CEO attitude towards the R&D people on the floor is very important	CEO fosters a culture of innovation	**ATI1**	
11	CEO should be involved from time to time in discussions with the CSO and the other team players	CEO holds frequent formalized meetings with R&D	**INV6**	
12	CEO does not need prior knowledge on the topic	CEO considers it an advantage to be untrained in science	**CEO-OTH12**	
13	CEO should offer trust to R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
14	CEO should offer freedom to R&D	Obtaining freedom to operate in an R&D environment requires the CEO to have trust in the R&D function and is part of a relationship of trust between CEO and R&D. This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
15	CEO should be involved in R&D	CEO holds frequent formalized meetings with R&D	**INV6**	
16	CEO should have an open-door policy	CEO fosters a culture of innovation	**ATI1**	
17	CEO should not meddle with the scientists	See above		**RD-OTH6**
Quotes made by R&D executive RDE27 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				

1	CEO science knowledge steers the development in the right direction	CEO fosters a culture of innovation	**ATI1**	
2	CEO has the same level of knowledge as R&D	See above		**RD-OTH15**
3	CEO acting as a scientist risks micromanaging people in R&D	See above		**RD-OTH6**
4	CEO without science background has more vision and the right experience	See above		**RD-OTH20**
5	CEO has focus	The attention of a CEO to find innovational opportunities in the market place, to focus on this opportunity and to set the boundaries in which to proceed	**ATT2**	
6	CEO relationship with R&D is based upon trust	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
7	CEO talks with all levels of the organization	CEO gets information from/discusses R&D with all levels	**CEO-OTH20**	
8	CEO needs to know whether he/she finds himself in 'quick sand' when talking to R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
9	CEO should really challenge us	CEO challenges rD1 technically	**INV2**	
10	CEO receives R&D messages which are written in a non-science language	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
11	CEO information from R&D should be accompanied by potential outcome of the R&D effort	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
12	CEO without a science background is informed about R&D projects in term of 'outcome' not in terms of 'science'	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
13	CEO needs to trust R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
14	CEO should be open but not always	CEO fosters a culture of innovation	**ATI1**	
15	CEO should have a strong business background more than a strong science background	See above		**RD-OTH19**
16	CEO with non –science background contributes to innovation and complements R&D knowledge	See above		**RD-OTH19**
Quotes made by R&D executive RDE28 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should act as an entrepreneur	RD-OTH28 CEO should act as an entrepreneur		**RD-OTH28**
2	CEO should have a clear vision	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
3	CEO of a start up should have specific knowledge of R&D thereafter it is not necessary	See above		**RD-OTH19**
4	CEO should be good networker (to look for new opportunities)	CEO fosters external collaboration to increase internal innovation	**ATI5**	
5	CEO expertise should not necessarily be in science but in market knowledge	See above		**RD-OTH19**
6	CEO should understand the science and technology behind R&D	CEO attempts to understand R&D expertise	**CEO-OTH10**	
7	CEO message from R&D should be presentable to anyone	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
8	CEO with science backgrounds drive the innovation	See above		**RD-OTH15**

9	CEO message are simplified to motivate the CEO to approve the proposal	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
10	CEO should have vast experience in leading R&D firms	See above		**RD-OTH19**
11	CEO has an amazing talent to understand the science right away and is driven by genuine interest	See above		**RD-OTH15**
12	CEO need for prior knowledge is driven by how good the scientific group operates	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
13	CEO message from R&D is transformed to a level driven by the CEO prior knowledge	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
Quotes made by R&D executive RDE29 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should be the individual with the most experience in the whole company	See above		**RD-OTH19**
2	CEO should always ask the question where do e go from here?	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
3	CEO creates a link between all levels in the organization	CEO gets information from/discusses R&D with all levels	**CEO-OTH20**	
4	CEO communicates with all stakeholders in the organization	CEO fosters internal communication	**ATI3**	
5	CEO should challenge the status quo considerably	CEO challenges R&D for efficiency	**INV1**	
6	CEO acts at all levels to create the link between vision and strategy	This refers to a CEO commitment – the creation of appropriate organizational structures for an innovation project to be successful	**COM6**	
7	CEO shows his personal commitment and engagement to the organization	CEO acts as a role model for innovation	**CEO-OTH17**	
8	CEO can steer development because he understands the science and has a science background	See above		**RD-OTH15**
9	CEO has a vision for the patient	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
10	CEO and CSO are complementary in innovation	CEO and CSO are innovative forces together	**CEO-OTH25**	
11	CEO considers it to be a disadvantage not to be a scientist because it results in non-integrated unstable long term visions	See above		**RD-OTH15**
12	CEO with science/entrepreneur capabilities has a longer term vision for the company	See above		**RD-OTH28**
13	CEO challenges R&D	CEO challenges R&D for efficiency	**INV1**	
14	CEO uses his network to build and foster R&D	CEO fosters external collaboration to increase internal innovation	**ATI5**	
15	CEO should show very strong commitment	CEO acts as a role model for innovation	**CEO-OTH17**	
16	CEO scientists may meddle with your research activities	See above		**RD-OTH6**
Quotes made by R&D executive RDE30 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO creates the right environment to innovate	CEO fosters a culture of innovation	**ATI1**	
2	CEO has the right vision	CEO sets the direction/goal and vision in which innovation to take place	**ATT2**	
3	CEO has the commitment	CEO makes available human and financial resources	**COM4**	

4	CEO articulates the vision in the company	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
5	CEO triggers to act upon the vision	CEO sets the focus and boundaries in which innovation to take place. 'Trigger upon the vision', means in this context that the CEO wants R&D to act in line with the direction and keep their activities within the boundaries	**ATT2**	
6	CEO gives his active support	CEO makes available human and financial resources	**COM4**	
7	CEO creates innovation across boundaries and interfaces	CEO fosters internal communication	**ATI3**	
8	CEO should establish an open and transparent atmosphere were ideas can be exchanged	CEO fosters a culture of innovation	**ATI1**	
9	CEO should generate trust and openness in order to create an environment of innovation	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
10	CEO without R&D knowledge is not prepared to invest time in discussions with R&D	See above		**RD-OTH15**
11	CEO with a global role cannot make time available to discuss R&D	RD-OTH 29 CEO should make time available for R&D		**RD-OTH29**
12	CEO learns R&D to bridge the knowledge gap	See above		**RD-OTH21**
13	CEO lack of knowledge is compensated by his/her experience	See above		**RD-OTH19**
14	CEO has a noble purpose	This quote or a quote similar to this quote was not observed during the interviews with CEOs		**RD-OTH1**
15	CEO needs a clear vision	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
Quotes made by R&D executive RDE31 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should bring people together	CEO fosters internal communication	**ATI3**	
2	CEO should be supportive of innovation	CEO fosters a culture of innovation	**ATI1**	
3	CEO message should be considerably simplified	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
4	CEO should be able to learn his expertise to R&D	See above		**RD-OTH19**
5	CEO should network considerably for R&D to profit from	CEO fosters learning in the organization	**ATI7**	
6	CEO should be more qualitatively then quantitatively oriented	See above		**RD-OTH3**
7	CEO should offer trust to R&D	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
Quotes made by R&D executive RDE32 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO needs a thorough understanding of the market	See above		**RD-OTH19**
2	CEO should have a good knowledge of the development process	See above		**RD-OTH24**
3	CEO does not need scientific knowledge	See above		**RD-OTH20**
4	CEO should have an open communication model	CEO fosters internal communication	**ATI3**	
5	CEO message from R&D is transformed, simplified R&D knowledge	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
6	CEO message should be simplified otherwise it is risky	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
7	CEO acts at a top level when they are as well top scientists and how to make money from the science	CEO top scientist/business man/women is ideal	**CEO-OTH41**	

Quotes made by R&D executive RDE33 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should drive the strategy	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
2	CEO should balance trust and challenge	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
3	CEO should trust the R&D organization	This quote refers to the concept of 'trust' and is therefore assigned to CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
4	CEO should not micromanage R&D	See above		**RD-OTH6**
5	CEO should challenge in order to trigger the conscience of R&D	CEO challenges R&D for efficiency	**INV1**	
6	CEO should ask questions sufficient to make people sweat	CEO challenges R&D technically	**INV2**	
7	CEO forces R&D to think differently	See above		**RD-OTH21**
8	CEO message is simplified	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
9	CEO learns from R&D	See above		**RD-OTH21**
10	CEO teaches the R&D organization about the business	See above		**RD-OTH21**
11	CEO is coached by R&D to understand R&D knowledge	See above		**RD-OTH21**
12	CEO knowledge from R&D is titrated to a common ground	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
13	CEO should foster transparency to instill trust in the organization	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
Quotes made by R&D executive RDE34 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should have the right attitude for innovation	CEO fosters a culture of innovation	**ATI1**	
2	CEO should commit for resources for a long term perspective and commitment	CEO makes available human and financial resources	**COM4**	
3	CEO should show trust in R&D and supports innovation	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
4	CEO should make clear that there is trust among the top management team members	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
5	CEO should have trust in R&D and be assured that the money is well spent	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
6	CEO needs to create a stable environment for innovation to take place	R&D executives argue that a CEO should be able to make sure that the environment to innovate is stable, i.e. that they van focus on their objectives without frequent changes in focus	**ATT2**	
7	CEO shows trust in R&D even when things go wrong	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
8	CEO should create an atmosphere of trust such tat scientist can explore new ways	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
9	CEO is capable to understand the science	CEOs should have some understanding of the science in which their firms are engaged	**CEO-OTH38**	
10	CEO should not mistrust innovation	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
11	CEO should have trust in the data	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	

12	CEO can challenge if he/she shows trust	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
13	CEO learns R&D about the business and the markets	See above		**RD-OTH21**
14	CEO receives simplified R&D know how	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
15	CEO wants to understand the data in order to be able to challenge it	CEO attempts to understand R&D expertise	**CEO-OTH10**	
Quotes made by R&D executive RDE35 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should make sure there enough resources	CEO makes available human and financial resources	**COM4**	
2	CEO should show trust: it comes when all the rest is there	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
3	CEO should show sincere interest	CEO acts as a sounding board	**INV3**	
4	CEO should have a clear strategy	CEO sets the direction/goal and vision in which innovation to take place. The attention of a CEO to identify innovational opportunities in the market and to develop an appropriate strategy and the direction in which to proceed: a vision for the firm	**ATT1**	
5	CEO should not exchange trust with money	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
Quotes made by R&D executive RDE36 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should be a scientist to some extent and have at least some knowledge	CEOs should have some understanding of the science in which their firms are engaged	**CEO-OTH38**	
2	CEO should build a network for R&D to become engaged in	CEO fosters external collaboration to increase internal innovation	**ATI5**	
3	CEO should attract the right people	CEO hires selects and develops innovative leadership	**COM1**	
4	CEO should be a trustworthy person	This quote refers to the concept of 'trust' and is therefore assigned to code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH3**	
5	CEO should be a stable factor in the organization	R&D executives argue that a CEO should be able to make sure that the environment to innovate is stable, i.e. that they van focus on their objectives without frequent changes in focus	**ATT2**	
6	CEO should have a clear vision	CEO sets the direction/goal and vision in which innovation to take place	**ATT2**	
7	CEO and R&D are at both ends of a knowledge gap	See above		**RD-OTH15**
8	CEO is teached by R&D about the science	See above		**RD-OTH21**
9	CEO is given a simplified message to some extent	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
10	CEO should have at least some knowledge about science	See above		**RD-OTH21**
11	CEO should stimulate people to innovate	CEO fosters a culture of innovation	**ATI1**	
12	CEO should trust R&D	This quote refers to the concept of 'trust' and is therefore assigned the code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
13	CEO should be trusted by R&D	This quote refers to the concept of 'trust' and is therefore assigned the code CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
14	CEO should bring in the money	CEO makes available human and financial resources	**COM4**	
Quotes made by R&D executive RDE37 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO knows the science really good and that is an advantage for a small company	See above		**RD-OTH15**
2	CEO understands the science so I do not need to explain it	See above		**RD-OTH15**

3	CEO who does not understand the science needs somebody to explain it	See above		**RD-OTH15**
4	CEO has a vast network from which R&D can profit and bring R&D into contact with other R&D people	CEO fosters external collaboration to increase internal innovation	**ATI5**	
5	CEO is a good communicator to direct and link all internal stakeholders	CEO fosters internal communication	**ATI3**	
6	CEO is a good communicator and is very approachable	CEO fosters internal communication	**ATI3**	
7	CEO wants to understand what is going on in R&D	CEO attempts to understand R&D expertise	**CEO-OTH10**	
8	CEO comes up with his own ideas	CEO comes up with new innovative ideas	**INV8**	
9	CEO contributes to R&D in those areas in which he has expertise	CEO interacts with R&D only in those matters he/she has personal knowledge in	**CEO-OTH3**	
10	CEO should develop a climate of innovation	CEO fosters a culture of innovation	**ATI1**	
11	CEO should have extensive industry experience	See above		**RD-OTH19**
12	CEO teaches me how to develop a product	See above		**RD-OTH21**
13	CEO needs to understand what we are doing in R&D and how it progresses	See above		**RD-OTH21**
14	CEO who knows about the science can more effectively secure money	See above		**RD-OTH21**
15	CEO explicitly wants to understand the science	CEO attempts to understand R&D expertise	**CEO-OTH10**	
Quotes made by R&D executive RDE38 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should not be the innovator of the company	See above		**RD-OTH16**
2	CEO should makes sure that innovation can happen	CEO fosters a culture of innovation	**ATI1**	
3	CEO should put the right people in place	CEO hires selects and develops innovative leadership	**COM1**	
4	CEO should have clear vision for the company	CEO sets the direction/goal and vision in which innovation to take place	**ATT1**	
5	CEO should make sure the TMT has the right skills	CEO looks for the best possible management team	**CEO-OTH22**	
6	CEO should be capable to communicate with everyone in the organization	CEO gets information from/discusses R&D with all levels	**CEO-OTH20**	
7	CEO should have different background from the science such that his/her knowledge is complementary	See above		**RD-OTH19**
8	CEO should have some degree of knowledge	CEOs should have some understanding of the science in which their firms are engaged	**CEO-OTH38**	
9	CEO should have an experienced CEO more than a CEO who know life science R&D	See above		**RD-OTH19**
10	CEO from outside the company may potentially see more opportunities than an internally grown CEO	See above		**RD-OTH19**
11	CEO who is not trained as a scientist is capable to ask the right questions the scientists would never ask	See above	**CEO-OTH12**	
12	CEO messages need to be simplified in order to see the advantage of a technology	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
13	CEO message which are simplified are not necessarily unscientific	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
14	CEO who is grown from within the company may focus too much on the operational aspects of the firm	See above		**RD-OTH6**

15	CEO should take a step back from R&D	See above		**RD-OTH6**
16	CEO should not need in depth knowledge of the field of R&D	See above		**RD-OTH20**
Quotes made by R&D executive RDE39 and assignment of the quotes to a 'PSN theme' or a new R&D theme ('RDOTH')				
1	CEO should motivate people to innovate	CEO fosters a culture of innovation	**ATI3**	
2	CEO should foster a policy on open communication	CEO fosters internal communication	**ATI3**	
3	CEO who has some knowledge allows easier science discussions	See above		**RD-OTH15**
4	CEO who offers a financial bonus does not necessarily motivate scientists	R&D scientists, although pleased with a financial bonus, are not necessarily motivated by it. Their motivation stems from their contribution to a new product, their involvement and the trust that they receive from top management with respect to their expertise CEO-OTH 31 'CEO and R&D should have a relationship of trust and confidence'	**CEO-OTH31**	
5	CEO can be convinced easier about a new innovation if he/she is knowledgeable about the subject and to explain my 'stuff'	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	
6	CEO requires non science data for him/her to be informed about R&D	CEO requires R&D data to be simplified for strategic decision and communication	**CEO-OTH6**	

*Involvement by CEO can be either technically (INV2) of for reasons of efficiency (INV1). Whether INV1 or INV2 was chosen depends on the case context

Appendix P. R&D interview observations

This section proceeds with an analysis of the interview observations on trust and complexity reduction. Because of the difference in degree of emergence of the concept of trust in the interviews of CEOs and R&D executives and the re-appearance of the concept of complexity reduction, it was decided to continue the interview analysis and observations for both. The first section presents the findings on trust and shows the concept of trust emerging in the interviews of the R&D executives. The second section in this appendix addresses the CEO's absorptive capacity.

TRUST

RDE7 is the CSO of a small biotech firm and a world renown scientist. He/she has made his/her name in industry and in academia in a particular area of biomedical science. His experience in dealing with chief executive officers has not been without problems. The fact that one of the drugs that were under development did not made it to the market, was - according to this CSO - caused by the fundamental problem of the difference in view between CSO and CEO. The CEO was a dominant-science educated - figure who managed with 'rigidity and control' and made decisions on his/her own without paying attention to the concerns and scientific/medical arguments of the CSO and his/her team. The failure of the drug would not have happened – according to the CSO - if he/she would have listened to the CSO and his/her team. The CSO therefore argues that a CEO

> *' should give time to the (R&D) people he/she is working with because you believe in these (R&D) people and you want to have a generous personal relationship with them, whereby you help (achieve) the objectives'*

The CSO therefore is convinced that a fruitful and effective relationship...

> *'would only work if the CEO had senior scientists who had a very good relationship with them and there was a bond of trust'*

however this bond of trust was harmed because the former CEO...

> *'was a very charismatic powerful individual who thought he could make his own judgements on certain aspects of (drug) development, even basic biology and in that process ... he convinced himself that his approach would be acceptable ... even when his own advisors and his professional people said no, he went outside and got other opinions and came back and argued (against us) .... he believed because he had a science background that he understood us when he didn't really and he wasn't aware that he in a way was being self destructive'*

The former CEO, although he/she had a science background, was not considered effective in dealing with the R&D function, because he was searching support for his/her own vision with outside consultants who could offer him/her the necessary ammunition to tackle the arguments of his R&D staff. After the fiasco of the failed drug development project, the CEO-scientist was replaced by a finance CEO (CEO2P in our CEO pilot study) who did not understand the science, and focused on the financial aspects (in order for the company to survive).When asked about the relationship with the finance-CEO, the CSO argues that:

'we trust each other absolutely'

This relationship is a relationship of trust between 2 individuals with 2 different educational and experiential backgrounds and who complement each other. However, this should be taken with some caution, as this CEO argued during the pilot interview that he hopes that

''The CSO is not deliberately misleading me'

Indicating that such a trust relationship is subject to personal interpretations. From the viewpoint of this CSO, this is an ideal situation as he/she argues that it is inappropriate for a CEO to meddle with the science activities in his firm. According to this CSO, a CEO should make available the resources but the strategy for the approach in getting a new product on the market should rest entirely with the R&D function. This first interview offered a first impression of the potential difficult relationship between CEO and R&D. Even if the CEO has a science background and has a sincere interest in the science, his/her interference with the science is strongly objected by R&D executives. The CEO should trust the arguments raised by the R&D function: without trust says this CEO – irrespective of the prior educational background of the CEO - a R&D intensive firm cannot be managed properly.

Besides commitment to the scientific exploration and the attitude of the CEO, **RDE9** however supports the CEO's point of view that he/she should double check the information received from R&D:

> *'he's a scientist ... but I think what is good with him is - and I think some people do not like it- but he is always double checking the information ... I like it personally because it means he's checking and I don't see this double check as a negative aspect...'*

The fact that the CEO double-checks the claims made by the CEO is not considered a sign of distrust by **RDE9**. It is not the first time that a 'double check' step made by the CEO is not considered a sign of distrust by **RDE9** (a CSO) and a university Professor. This is likely due to the fact that the essence of the scientific exploration is the possibility of one's work to be checked and rechecked and is therefore not considered as a sign of distrust,

but rather a normal part of the scientific endeavour. That this double-checking was severely disapproved by **RDE7** is likely caused by the fact that **RDE7** – an academic with a strong international prestige – had a difficult time being challenged by a business executive on his/her terrain.

In the case of **RDE9**, the essence of CEO double-checking is to make sure that he/she has the correct information. **RDE9** argues that it is imperative for R&D to gather the right information for the CEO to take the right conclusion:

> *'What I want to say that he's understanding the science and where we want to go that's really important for the vision and he needs to understand exactly what we do ..... its very important that our CEO has the right information, not being distorted by somebody else in between and I think that's probably one of his strengths to recognise that and make sure that he has the correct source of information, that's very important...'*

The fact that this R&D executive argues that he/she should make sure that his/her CEO receives the right information is a source of trust between both. Therefore, in this case, the CSO has no issues with his/her CEO double-checking the information, as this double-checking already took place by **RDE9** in an attempt by the CSO to build trust between him/her and the CEO. If the information were not correct this could potentially lead to a trust fracture between the two actors. It must be emphasized that this CSO was a recent hire by the CEO and the CSO obviously wants to make sure that this relationship is functioning properly from the start. In the case of **RDE7**, the CEO was hired by the board and pushed into the company to work with **RDE7**.

When asked what the role of the CEO is in innovation, **RDE11** argues that the CEO should offer freedom to explore new ideas under the leadership of the CEO:

> *'...the chance to have is coming with - sometimes crazy - ideas to the CEO and he/she tells me: ok just do it... of course there's some questioning, of course he knows what it's it about, it's not like he's taken by surprise but still: .... it's something special and there's really, there's confidence and the freedom that I've been given where the CEO tells me just do it, let's go that way, it's a good idea, let's do it!'*

This trust - made explicit by the CEO offering freedom to invent and innovate - is also articulated by **RDE12**:

> *'I think certainly trust and belief in the team is very important'*

The concept of trust by the CEO in R&D is considered a condition sine qua none that - in the case of **RDE14** - does not require too much discussion:

> *'I am trusted that is not the issue..'* and *'trust is always important'*

RDE15 , a senior vice president of a life science firm discusses how trust develops when firms change from small start-ups to larger firms:

> *'... I think our company is actually a very good case study ... when we were a small start up it was very good to have a very involved knowledgeable scientist as a CEO ... I think at that moment that was also quite necessary for the outward facing discussions but also for the inward facing discussions in a very young and less mature company... (on the other hand) we have now extended quite a bit ... so I do fully understand the need for a different type of CEO that is more commercially oriented which has less R&D or life science experience but should trust us to kind of make the translation into what it can actually mean for the market and to make it a commercial success, so with this respect I don't think its absolutely necessary that our current CEO has a lot of R&D experience or he should be a scientist but he should of course understand the market very well and understand what the R&D unit should together with R&D unit what would make the best sense for the company.*

The argument made by **RDE15** is that in small firms, the CEO is generally knowledgeable in the science that is conducted in the firm and while the firm is growing the need appears to have a more commercially oriented CEO, who is less versed in the firm's science and technology, but will then need to develop trust is in his scientific cadre. In other words, **RDE15** argues that by having a less knowledgeable CEO, the higher the need for the trust level of the CEO in R&D. This links both the concept of knowledge to the concept of trust in that the less prior knowledge the CEO has, the less his/her absorptive capacity is, the more the knowledge will need to be reduced in complexity and the more trust the CEO will need to have in R&D that they are informing him/her correctly. In other words, there seems to be a relationship between absorptive capacity of the CEO and the trust he/she has in innovation.

This concept of prior knowledge is also corroborated by **RDE16** who argues that prior knowledge is helpful for the R&D executives, but entails some 'risks'. On the one hand, prior knowledge of the CEO makes the challenging process and the decision making process more effective because a knowledgeable CEO is able to interact in a meaningful way with R&D. However:

> *'... I think it is an advantage to have a scientific (CEO) but you need to be very careful that at the end of the day you have to make products and not only do the science ... so I think ... it has an advantage because the bigger advantage about challenging and understanding, capturing the complexity so that you (RED16 refers to the CEO) know when you (the CEO) can take the right decision also from your (the CEO) own experience and not only because your people tell it- I mean you have to trust your people no problem - but if you feel as a CEO self confident that this looks: ok we can go the next step...'*

RDE16 argues that a scientific background of a CEO may prove to be useful but entails the risk of over-involvement - even meddling - with research and to deviate from the objective of the firm, a comment that was also raised by the CEOs during their interviews. **RDE16** also refers to the fine balance between CEO challenge and CEO trust:

> *'... you need to strike that balance and as a CEO pushing is very important but also feeling ok I've reached a limit I feel that and I trust also my people when they say we cannot do this or I think we will then take a decision which is not ready then also listen to it and I think ... if you strike that balance , I think you have a key for success and that's an important one'*

RDE16 also reverts the trust equation; not only should the CEO trust R&D , R&D executives should also be able to trust the CEO in his/her decisions with respect to where he/she wants to bring the firm:

> *'you (R&D) can only feel confident in the future and in the way your company is going if you can trust what he (the CEO) does .... you need to trust him/her ... '*

RDE33 argues that trust and challenge should be in balance:

> *'I think it's a mixture between challenging, challenging on a content side, certainly not in a deep scientific level but understanding what's going on, on the other side a supporter so the balance I think between trust and challenge for me on the CEO level is absolutely essential because you can deconstruct any R&D organization if you ask the nasty questions, you just don't always have answers and that's where the trust part comes in'*

RDE17 argues that trust is one of the key characteristics of a CEO who runs a life science R&D firm especially when the financial pressure become intense:

> *'... I expect a very trusting relationship because there are inevitably times when he or she, the CEO is going to get pressure on finance ... so there needs to be a lot of trust and loyalty between those two (the CEO and the CSO) and that's important because you just see it all the time that some VC's have a different view on the science so the CEO might then say ok well … there's got to be a lot of trust, there's so many pressures coming externally on that relationship...'*

RDE18 boldly puts trust at the same level of importance as vision for a life science R&D company:

> '.... So ok vision is the first point, (but then again) just as leadership you need to build trust...'

RDE19 argues that a relationship of trust may be harmed when CEOs use too many consultants to double check his/her scientist's arguments. From the R&D executives point of view, a CEO who double-checks the claims made by his/her scientists is actually in the process of building trust in his R&D function while at the same time risking that the R&D function may perceive this as a sign of distrust:

> *'we see it (the CEO asking consultants to give their advice on the claims made by his scientists) as a matter of fact I would say building his trust; I don't know what he thinks but the way I see it is that not being an expert in what we are doing he needs to get external input on whether things are being done properly, … our perception is maybe well he's not really trusting us, we're telling him something but he wants to hear it from someone else. That his purpose may very well just to understand better what we are doing but then on the other hand if he doesn't understand he can always come and ask and get the information there, there are different ways...'*

> *'what I expect from him/her is trust in that we are putting together'*

The concept of trust is also linked to the a priori concept of involvement and the deteriorated version of involvement: intervening in or meddling with the scientific activities of R&D. **RDE20** argues that:

> *'the fact that ..(he/she).. will mingle with my scientists ... that would be for me a message that he doesn't really trust what I do but then again its nice if he wants to be involved in the sense that he wants to be updated..'*

RDE20 again refers to the link between trust and knowledge and decision making as follows:

> *'... (the CEO) maybe a very clever person who knows its limits, but if you don't understand the details then you have to trust the people who are giving you recommendations, if you're clever and you have chosen your people properly and you trust them, even if you don't understand it …'*

The concept of trust is not always articulated explicitly but is also implied by the fact that CEOs offer the CSO the opportunity to explore novel principles that may make business sense. The fact that CEOs allow the R&D function to explore novel paths that have not been explored before is a clear sign of trust in his/her scientists. As stated by **RDE21**:

> *'I think it's very important that my CEO gives me the opportunity to explore novel principles, novel applications of (name of chemical substances) but always keeping in mind what is relevant for the business, meaning that I'm not wasting an awful lot of money, resources...'*

This CSO also balances trust versus prior knowledge, in that he/she argues that it is advisable to have a CEO who is knowledgeable about the scientific principles that govern the firm's R&D and the R&D knowledge that is generated in the firm. Such prior knowledge prevents the need for 'trust' between both actors because their interaction is based on the exchange of verifiable and challengeable data . In this case a relationship based on trust – although valuable in its own right, but which may be misused or disappear– is not required. In other words, because trust is such a delicate concept, it is better to replace trust by data checking:

> *'I've seen other CEO's in my previous life who didn't know the science so well and I think that is a limitation, if such persons completely have to trust their CSO … I think that makes such a person (the CEO) fully dependent on others and also he/she cannot have a good judgement on things which are happening in the company …'*

From this perspective the statement made by the CEO2P of the second pilot firm and who is not knowledgeable at all about the science taking place in his/her firm speaks volumes:

> *'I hope that my CSO is not deliberately misleading me'*

In other words, although a relationship of trust seems to be worthwhile, it is not necessarily the optimal situation because scientists prefer a CEO who is knowledgeable

about the science but also about the business and the market. Therefore, as argued by the R&D scientists during these interviews, a combination of a top scientist with the personality and business acumen of a top business man/women is considered the ideal CEO of a life science R&D firm. It is acknowledged that this constitutes a rare breed of CEOs because it combines two characteristics that are considered contradictory: the outgoing character of a business executive with the inward looking attitude of a scientist. On the one hand, if the knowledge base of both actors is similar, trust as the basis of the relationship can be replaced by a verifiable data exchange. On the other hand, if the knowledge base differs substantially, the complementarity of knowledge becomes increasingly important such that both actors learn from each other, but there will be a strong bond of trust if the relationship is successful.

As argued by **RDE21** when discussing the knowledge gap with the CEO:

> *'What is the gap? I've been in (name of scientific discipline) for so many years, so when we started four years ago we made (name of chemical substances) which were good against (name of disease area) and you really need a very high affinity, a high strength and the antibodies which we have are ok but they should be better if we really look at the competition. It was important to improve on that, then I can say something I know that matters and the CEO doesn't know, that is a gap in knowledge, is that essential? Not at all because he really trusts me...'*

When asked about the role of the CEO in innovation, **RDE24** refers to the balance between the challenge by the CEO - for which knowledge is required - and trust by the CEO:

> *'… I think his role should be a supportive role, a role in which he, first of all trusts his employees involved in research and development in what they are doing but at the same time be critical to what they do, I mean it comes from both sides a respectful lets say relationship so to speak, professional relationship in which there is trust but at the same time there's also room to challenge each other, I think that this is important to really push, push is perhaps not the right word but to foster a healthy environment, I think that is a very important aspect.*

Knowledge generated in a life science R&D firm can be divided in two fractions: knowledge that the CEO is able to challenge because of prior knowledge available through education or experience and knowledge conferred to him by his/her R&D scientists that he is unable challenge because of lack of knowledge and for which he/she needs trust to handle it. **RDE24** remarks that the trust from CEO in the R&D function, is

only one part of the equation: there is also the need of trust by R&D scientists in their CEO:

> *'Well how do you define it? … at least the way I see it is that within an organization like ours you have some sort of relationship with each other from a professional point of course and in any relationship there should be trust - I mean by trust: this person is really here for the benefit, he's really not working much on agenda but really to make the company better... that you do not set up your own interest … sometimes it happens that the CEO says something to me and I'm really bothered by that, I'm actually angry but then I always try to understand because I trust the CEO, because if I wouldn't trust the CEO then probably I wouldn't work here anymore ....'*

RDE24, RDE25 and RDE26 consider the bidirectional aspect of trust (CEO trusts R&D and R&D trusts CEO) as a condition sine qua non:

> *'... for everybody within the company equally important that they can trust not only scientists but also of course each other and not only the CEO but each other but of course I mean if there was doubt in my scientific capabilities then of course then I trust that he would tell me that 'he can only sell the data when he really hopes and believes ... there's an effort to understand the data but of course there's always the trust that what I deliver to him is of course correct at least to the best of my knowledge'*

RDE25 considers trust as one of the key aspects of his/her relationship with the CEO. According to **RDE25**, trust is bidirectional in that:

> *'It's two-way, he/she trusts you because of your science and you trust him/her because of his/her knowledge of the market. In addition, I can trust him/her because I can just show the ideas you have, you know that he/she trusts me'*

The bidirectional aspect of trust is also corroborated by **RDE26**:

> *'I think he/she has to give the trust to the CSO and his team and the scientists in his/her team go for it ... (but) ... I think that's important that we also can trust the leadership by the CEO and that we don't have to be afraid of the CEO to discuss ideas openly and that its very, that everything can be discussed very openly without any wrong feelings I think that's very important'*

'...that the CEO has to give you the time and the trust to discuss scientific findings and topics on your way and I think that's important'

'....I think he really has to give the trust towards the people on the floor, to give the people the opportunity to learn and to achieve their objectives and to think together in a team how to reach …'

RDE33 also discusses this bi-directional aspect of trust:

'I think this is getting to – what I said at the beginning was that the very difficult balance between challenge and trust so just enough challenge to trigger the conscience in the R&D organization that we constantly need to challenge ourselves, but not challenge to the point where it disrupts R&D and innovation, innovative activities that's what I mean really, so its really the trust of the CEO into the R&D organization but autonomous sounds like leave it alone it's a black box, that's not what I mean and yes it also works the other way around there needs to be trust from the R&D side into the CEO that there is a sustainability in the approach to innovation …'

RDE36 argues that a CEO must be:

'an absolutely trustworthy person and has a cool way of handling if there's some hick-up in one of the programs and people get a bit nervous that they see that the CEO is sort of, has things under control and that there's no reason for panic'

The CEO should also trust the R&D function to increase its output. As **RDE24** argues:

'Well sometimes he thinks along in that way although he also then in a way trusts that we already …'

RDE26 continues on trust versus bonus and financial rewards:

'… at least what I know, but compared to financial or salary or bonuses I think at this moment for me that's less important than trust and maybe after trust I think for me at least learning because at this moment ok I'm still young and I know I still have to learn a lot so first thing for me is ok trust, he trusts you in what you are doing so it gives me the opportunity to work in a team, in a company to learn'

and on trust and freedom:

> *'Yes he has to give you the freedom, he has to be involved in the discussions but he has to give you the freedom to operate and again to openly discuss and to do what you are thinking that's what's right so I think its also important for the CEO to do that …'*

According to **RDE27** the concept of trust is also linked to credibility as follows: when trust is developed between two actors, the exchange of information is based on the trust that one of the actors has with regard to the other actor. It should be stated here that the CEO of this company has no scientific degree at all and succeeded a CEO with a considerable scientific background. The concept of trust therefore plays to it's full extent:

> *'my current CEO has an extremely developed analytical brain, immediately listens very carefully and so it becomes extremely critical... you have to make sure that people start to believe what you're saying, build credibility, so the communication between me and him/her now is more based on credibility …'*

The absence of in depth knowledge forces the CEO to check and double check, in order to make sure that the trust can be build between him/her and the R&D function:

> *'…he needs to know if he's in quick sand or if solid ground so I would think that more gradually as he gets to know the people better then he's going to depend more on people but now I think it's the best thing he can do is double check and double check '*

When asked what is important for him as a senior scientist vis-a-vis the CEO, **RDE27** comments:

> *'Well trust is of course number one, I don't expect a CEO to be always completely open and the other way around I mean people have certain responsibilities and I think the word responsibility means that it's your thing, you collect all the information you need to execute that responsibility when you do it and if it fails then you'll figure it out later, so I don't want him to inform me about everything, so openness is not the most important, trust, trust is more important because if you're open it means that you know you do everything together and with trust you can go and do your own thing and be more efficient'*

On the relationship between openness and trust **RDE30** comments as follows:

> *'Most important between trust and openness I would categorise them at an equal level, I think first to develop some trust but trust you can build very quickly if you know that you can talk openly to each other so it's a little bit the chicken and the egg situation.'*

The trust equation is not unidirectional but bifocal in that the R&D function believes in the CEO. **RDE33**'s comment that the 'trust' part comes in when the answers are not coming in' indicates, that trust and knowledge are intrinsically linked and more so if the knowledge levels between two actors start to differ substantially. In addition:

> *'What I meant primarily was the trust into the R&D organization is that they're doing the right things because I don't think as a CEO you can micro manage an R&D organization and you have that patience and trust go together...'*

RDE34 explores the concept of trust from 3 different angles. First, the financial angle:

> *'....trust means that the money, the company the corporation puts into this is believed that's worth to be spent.'*

Then, from the long term commitment:

> *R&D is nothing which you can very much titrate up and down, you can do it on a minor scale but you cannot ramp it up like hell, double the investment within one year and then drop it the next year because we have long term commitments with external partners and so on, so trust in this respect means we need a long term perspective that's dependent on the growth from the company and that we maintain a stable investment, this is for me the trust, ...'*

and from the impact at all levels:

> *'its becoming very much from bottom up: scientists are reading papers, they are visiting conferences and the environment needs to be there to be open and trustful that they can bring their innovations to a kind of lets say auditorium''...'*

> *'the more you can trust the more you can challenge'*

KNOWLEDGE COMPLEXITY REDUCTION

Because of the similarity in degree of emergence of the concept of complexity reduction in the interviews of CEO and R&D executives, it was decided to continue the interview analysis and observations for complexity reduction.

RDE8 is the senior director of the company where **RDE7** is the chief scientific officer. He/she has a more balanced view of the role of the CEO vs the role of the CSO. In his/her opinion, it would be difficult to accept that a CEO would rely completely on the advice of an academically oriented CSO and should look for outside and independent advisers in order to obtain a balanced view of what is being conducted in his/her firm and it is the CEO who should have the final word even in R&D, an argument that would not be readily supported by the CSO. However, the CEO should be a good communicator and a good listener such that he can differentiates between the academic value of the scientific proposition and the commercial value. Therefore, in view of the CEO's expertise, he/she argues that:

> *'He does not need to know the ins and outs of the detailed science and that is one of the dangers is that when you talk to an academic (chief scientific officer) , he/she will fill you in with facts that are not crucial...'*

and therefore the CEO

> *'should be able to cope with the academic pressures'* and *'should be able to see the value of science and how to achieve that value'*

According to **RDE8**, a CEO can only focus on the essentials of the R&D message if he/she is not drawn into the details of science but receives a scientific message that is reduced in complexity:

> *'I don't regard simplification as sort of a patronising thing, to simplify the science is not something you do to patronise people who don't understand science, ... to simplify science and its objectives is a key commercial art anyway because you know what's key at the end of it is still down to the objectives, the value, the time it takes to get there'*

and:

> *'… he/she (the CEO) does not want the details of the science. He /she wants the basics and when it gives the answers, this is sufficient for him/her to run the company and the innovation'*

The concept of complexity reduction that is described above and which was identified during the CEO interviews, is raised here by a member of the R&D function and

considered a useful approach. It should be emphasized here that **RDE8** was appointed by the CEO to assist him/her in addressing his/her questions that was the result of the absence of any scientific background of the CEO and to assist him in making the 'de-complexification' step and to extract from the knowledge the core message that is required to allow a challenge to take place and to make decisions.

According to **RDE9**, the data transmitted to the CEO requires a simplification step in an attempt for the CEO to understand the data:

> *'... sometimes we need to simplify a lot because we want to bring something into the playing field ... then we need to simplify a lot but he's always asking what did we do, in fact so he wants to know what we are simplifying, so we cannot just tell him that it works in exactly the same way, an animal cell compared to a plant cell, we can tell him the mechanism is the same but the individual steps are different and then he wants to know how different are they, how difficult it would be to try to even something directly, how long would it take, what this team needs to discover before it can be – so he wants to know, we have to simplify a lot that's sure but I think its linked to the time we have with him but in some cases he has the details and he can add another hour to a meeting that's fine, if he needs it we do that, he wants the facts I think all the time'*

A simplification step however is not always without risk according to **RDE11**:

> *'... there could be a risk (that simplification leads to the wrong decision) but I think the responsibility would lie with me to make sure that the CEO has understood the story ... and then the simplification is more to make the topic more accessible to the other people especially for example the finance people who are actually going to put the money on the table, they want to know what they're going to get back for it...'.*

However the simplification also entails a les scientific rationale of the topic and a more financial operational driven simplification:

> *'Well I guess you know the answer right so its less and less scientific, its more and more simplified and more and more based on timelines and deliverables so it starts by … at least it starts really the concept and the background, the story behind and then after that it gets into practical steps, how many FTE's, how long will it take, how much work cost and the higher up you get the less its scientific'*

The concept of reducing the complexity of the R&D knowledge is considered a responsibility of R&D executive **RDE12** in order to make sure that the CEO is capable to absorb the new knowledge:

> *'it's more a responsibility that you have to tell your story to the management team you have to make sure that they understand this, ... you have to translate the project and this takes a lot of my time because it's not my core activity ... what I have to make sure is that I first do the basic scientific checks on the project before presenting it ... it's a responsibility that I should not forget doing '*

RDE14 argues that the complexity reduction step is not only an exercise conducted to inform the CEO and make sure he/she understands the message. In addition to 'teach' the CEO about the R&D know-how the complexity reduction step allows the R&D executive to focus on the message and the objectives of his/her research. This is linked to the concern of CEOs that research in their companies may become too much academically oriented or for the sake of technology:

> *'... you need to reduce it in its complexity in order for them to grasp it quickly, it helps a lot because it focuses also the thinking about your own issues ... I don't see this as an issue, I have to be able to explain this to my wife for example'*

The argument that the science should be transformed to a level that the R&D executives' wife is able to understand' is analogous to the comments made by CEO5 that he should be able to explain 'the data to his son'. In this context, the complexity reduction of R&D knowledge is both advantageous for the CEO in that it allows him/her to absorb the knowledge, thereby modifying the knowledge or requiring the knowledge to be modified to a level that is aligned with his/her absorptive capacity while at the same time allowing the R&D executive, while doing this exercise, to critically assess the value of the knowledge and its potential for the firm.

When referring to the major role of the CEO in innovation, **RDE15** argues that it is the CEOs capability to

> *'...recognise the value of the technology and research that we basically supply and hopefully continue and to translate that together with other people into a commercially viable success for the company so that means recognising... the short term and the long term value of the R&D that we do and how that translates into a product that is very attractive for our potential customers'*

In order for the CEO to be able to value knowledge – as part of his/her absorptive capability– it is important for R&D executives 'gauge' the absorptive capacity of the CEO:

> *'what we try to do is basically try to understand what level he has and bring the main messages at that level and fill them in with the science connections because of course he is a PhD and therefore he is very well versed in (scientific discipline) so that already helps the fact that we can go to a certain depth, we don't have to really drill it down '*

This exercise of R&D executives to assess the level of scientific knowledge of the CEO and then fine- tune the R&D knowledge to a level that the CEO is capable to evaluate it (and eventually to assimilate and exploit it) supports the previous argument that the complexity reduction step is titrated to the CEO's absorptive capacity. The capability of a CEO to absorb new knowledge, a constituent of the overall absorptive capacity of the firm, is driven by his/her previous knowledge and – in case the level of such previous level of knowledge is limited – will require the modification of knowledge to such a level of complexity that the CEO is capable to absorb it. What is observed here is the creation of equilibrium between two actors with differing levels of knowledge. The objective of the complexity reduction is also, according to **RDE16**, to make clear the goals of the knowledge and why it was generated in the first place:

> *'...the most important one is if you do an experiment there is a certain goal in the experiment so I think the presentation of the results should be in the context of why did we do this experiment, for what was it intended to be used and so what are the results telling us in the big context so the presentation is a reductive presentation but it has a certain goal it is really what we wanted to do is that because we wanted to go there...'*

RDE17 is a chief scientist led by a CEO with a strong scientific curriculum and extensive experience in life science R&D firms. His relationship with the CEO is such that there is no need for complexity reduction because:

> *'... in this case with the current CEO I can talk on the same level because he has a scientific background and he understands, because I think he performed the role that I do now himself for 12 months before he recruited a CSO, so I can talk to him very knowledgeably on the same level, I don't have to modify how I talk'*

RDE18, a colleague R&D senior scientist of **RDE17** and working under the same CEO leadership, also argues that a complexity reduction is not a good approach because it may lead to the wrong decisions.

> *'No, I don't think that it should be a good idea because before you are –either- able to manage a pharma company or not, you know ... you need some basic knowledge of drug development and this knowledge is crucial and its part of knowledge which you should know, if you want to be, to stand in front of any audience which are only be all the CEO's you need that… because it could lead to wrong decisions, it could if there is a strong misconception …'*

RDE20 argues that a de-complexification step is not only required for the CEO to understand but to make sure that the R&D knowledge is presented such that the CEO is not confused:

> '*I simplify the message for him to understand and not necessarily because he doesn't understand, I think in particular in my area he's quite confident but just because I see him once a month and if I bother him with the latest analytical problem he will get confused*'

RDE21 also refers to the complexity reduction step as one of the steps required to do the 'selling story' and the use of the simplified message to attract new capital, new collaborators, new investors. This was also argued by **RDE7** and by CEO1. In addition, **RDE21** finds his/her CEO to be capable to the reduction exercise him/herself in order to do the story-telling:

> *'No I think that is the art of the job also the CEO masters very well..'*

RDE23 adapts the R&D knowledge to the level of the CEO thereby reducing the complexity to a level that he/she gauges to be present in the CEO. As was stated above the CSO tries to find a common platform on which the science data can be placed such that both scientists and non-scientists can discuss the data:

> *'... I would try to adapt to the person and depending if it would be a financial guy you would use more financial data at the end of the day you would say look that we could make a business plan - I always say to my people here also if you go to a meeting you have to know who's there... '*

When inquiring about the concept of knowledge complexity reduction, the **RDE24** responds:

> *'I do simplify the message but not that's incorrect to leave out unnecessary details, I do that yes unless he asks more specific and then I explain in more detail. I speak in a different way with*

> *him such that the knowledge becomes absorbable and speak with him other than I do with my team'*

In view of the knowledge transfer from R&D to CEO, **RDE27** argues that the 'language of R&D' should be transformed such that the content matches the absorptive capabilities of the CEO:

> *…'the language (used in the communication of R&D knowledge between the R&D function and the CEO) has to match that of the understanding of the CEO'*

RDE27 has experienced two very different CEOs, the first CEO was a top-level scientist while the CEO who succeeded him/her is a finance trained CEO. **RDE27** comments:

> *'I think the difference between the two CEO's I needed perhaps a lot fewer words to explain what I was doing to the first one, I could have explained it in five minutes'*

The message that is communicated to the current CEO should be simplified in order for the CEO to become motivated according to **RDE28** (a colleague of RDE27):

> *…'when the scientific team drive the innovation I think they need to be able to simplify and to be able to explain and let's say motivate the CEO to go after it...'*

On the transformation that R&D knowledge undergoes during the communication to the CEO, **RDE31** comments that:

> *'… I (the CSO) have not so much detailed knowledge... the more and more you go through the upper regions in a firm you need to get more and more abstract...The complexity of R&D knowledge is reduced tremendously. It is also risky to convey detailed knowledge to the CEO... it could be disastrous for the company...'*

Transforming R&D data for communication also learns the R&D function to think about the business context of their activities. According to **RDE33**:

> *'the data from R&D are being transformed, or modified such that it becomes open to challenge, the challenge is to simplify data, actually learn R&D, it is the coaching R&D to become a business organization, its for me a vital part of what's happening.*

The exchange of knowledge between CEO and R&D is a learning activity that goes both ways by which knowledge is 'titrated' to find a common ground:

> *'....we titrated ourselves or each other really to a middle ground where we can talk about value and risk but still having a tie to the actual project that also the R&D colleagues could support...'*

and

> *'the simplification process is also a very valuable process for both parties to learn from each other'*

On the topic of complexity reduction, **RDE33** comments that if the data would not be de-complexified, it would paralyze the R&D function:

> *'by putting too much emphasis to the technical detail you may oversee the big picture. A clear answer from my side : if you do not simplify, it's a nightmare and then you can imagine how to prepare for such kind of a meeting, this is the next and you will completely eliminate lets say the driving force in the team because they are focusing what may happen if he's asking for this, are we prepared, do we have backup for this and that, then we are not focusing on the progress but on the status quo of the project'*

In a way, it also educates the R&D function:

> *'So in fact the whole exercise of between transforming the research data into a simplified form is not to bridge the gap with the absent knowledge in science of the CEO but to make it available for challenge...*